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OLIN MATHIESON CHEMICAL CORPORATION

RESEARCH

DIVISION EXPLOSIVES

CONTRACT NO. DA-22-072-ORD-579 DATE APRIL 10, 1955

REPORT PERIOD JUNE 15, 1953 THROUGH FEBRUARY 28, 1955

FINAL REPORT

TITLE

RESEARCH AND DEVELOPMENT IN CONNECTION WITH THE DESIGN, DEVELOPMENT, MANUFACTURE AND TESTING OF AN ELECTRIC AND NON-ELECTRIC BLASTING CAP

Ordnance Corps
Department of the Army
Project [illegible]06

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OLIN MATHIESON CHEMICAL CORPORATION
Explosives Division
Research and Development Department
Detonator Section
East Alton, Illinois

Commanding General, Picatinny Arsenal
Contract No. DA-23-072-ORD-579
Ordnance Project TA3-5306

RESEARCH AND DEVELOPMENT WORK IN CONNECTION WITH THE DESIGN, DEVELOPMENT, MANUFACTURE AND TESTING OF AN ELECTRIC AND A NON-ELECTRIC BLASTING CAP

Final Report
For the Period
June 15, 1953 through February 29, 1956

April 10, 1956

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RESEARCH AND DEVELOPMENT WORK IN CONNECTION WITH THE DESIGN, DEVELOPMENT, MANUFACTURE AND TESTING OF AN ELECTRIC AND A NON-ELECTRIC BLASTING CAP

1. ABSTRACT

1.1 On June 19, 1953, Olin Industries, Inc., (since August 31, 1954, Olin Mathieson Chemical Corporation) accepted Contract DAI-072-501-ORD-(P)-12 issued by Picatinny Arsenal to design, manufacture and test an electric and a non-electric blasting cap for use by the U. S. Army Engineers Corps. This contract was amended by eight supplemental agreements and on October 7, 1953, it was replaced by Contract DA-23-072-ORD-579 which has been amended by one supplemental agreement. The new contract provided for experimental work through February 29, 1956.

1.2 In general, the contract required that the blasting caps should, when packaged, stand the usual temperature and humidity cycling tests, jolt and jumble test, high and low temperature storage and function through a temperature range from -65°F to 125°F. The caps were to be 0.241 - 0.004 inches in diameter and have a minimum length to detonate a half section of a standard military TNT Block. The electric blasting caps were to have a resistance between 1.25 and 1.80 ohms with No. 22 copper wires 12 feet in length. They could not fire from 0.20 amperes of current but must fire from 0.45 amperes of current applied for 50 milliseconds. They were required to fire after being subjected to 100 psig water pressure at 65°F + 5°F for 4 hours. The non-electric blasting cap had to be suitable for manual attachment to, and had to reliably function with safety fuse, detonating cord, and other standard firing devices.

1.3 The problem of selecting an adequate ignition system was solved by the development and preparation of a three component, Basic Lead Styphnate igniter. An effective waterproof closure resulted from the development and application of a polysulphide rubber seal and special shell mouth crimp.

1.4 High temperature (71°C-160°F) storage of pressed TNT Blocks and non-electric blasting caps proved that the pressed TNT definitely changed - approaching cast TNT in its relative insensitivity to detonation by a cap after one month's storage.

1.5 One thousand live and 150 inert electric caps along with 1,000 live and 300 inert non-electric caps have been shipped to Picatinny Arsenal for evaluation.

1.6 Picatinny Arsenal requested that the following nomenclature and P-numbers be used on the drawings, prepared in connection with the work on this project. They are appended.

Title	Drawing No.
Cap, Blasting, Electric, T6-Assembly	P-88398
Cap, Blasting, Electric, T6-Details	P-88399
Cap, Blasting, Non-Electric, T7-Assembly and Details.	P-88397

This is the final report on Contract DA-23-072-ORD-579.

April 10, 1956

Contract DA-23-072-ORD-579
Ordnance Project No. TA3-5306

2. INTRODUCTION

2.1 June 19, 1953, Olin Mathieson Chemical Corporation (then Olin Industries, Inc.) accepted Contract DAI-072-501-ORD-(P)-12 from the U. S. Army, Ordnance Corps, Picatinny Arsenal to design, develop, manufacture and test an electric and non-electric blasting cap for use by the U. S. Army, Corps of Engineers. The contract covered the period from June 15, 1953 through January 15, 1954.

2.2 The original contract required that the electric and non-electric blasting caps should:

(1) Be fabricated of stable and compatible materials to give a maximum shelf life, which may be selected by the contractor, but must be approved by the Project Officer.

(2) Be capable of functioning effectively under the following conditions:

(a) Between temperature limits of -65°F to 125°F after being subjected to the temperature and humidity cycle prescribed in MIL-STD-304 when packaged.

(b) After being subjected to the Transportation Vibration Test prescribed in MIL-STD-303 when packaged.

(c) After being subjected to the Jolt Test prescribed in MIL-STD-300 when packaged.

(d) After being subjected to the Jumble Test prescribed in MIL-STD-301 when packaged.

(e) After storage between a temperature range of -80°F and +160°F at any condition of humidity when packaged.

(4) The use of strategic materials is prohibited and the use of critical materials kept to a minimum.

2.2.1 In addition the electric blasting cap should:

(1) Have an electrical resistance within the range of 1.25 - 1.80 ohms with No. 22 copper leg wires 12 feet in length but once the desired resistance is established, it must be maintained at ± 10 per cent.

(2) Fire after being immersed to a depth of 25 feet in water at 65°F ± 5°F for 4 hours.

(3) Not fire when a current of 0.20 amperes is applied to the lead wire for 5 seconds, but shall fired when a current of 0.45 amperes is applied to the lead wire for 50 milliseconds.

2.2.2 The non-electric blasting cap should:

(1) Reliably fire when subjected to ignition by safety fuse, detonating cord, and standard firing devices.

(2) Be capable of being manually attached to safety fuse, detonating cord, and standard firing devices with a waterproof connection.

2.3 The contract also required that the work be performed in accordance with the following procedure.

(1) Conduct engineering studies and prepare preliminary designs of a non-electric and electric blasting cap.

(2) When preliminary designs warrant, manufacture and test components and assemblies to determine if the proposed designs are satisfactory.

(3) Upon completion of designs, manufacture 300 caps of each type for Proving Ground evaluation tests.

(4) If, as a result of Proving Ground evaluation, changes in design are warranted, incorporate changes into the design and submit for retest a maximum of 300 of the type altered.

(5) Upon approval of acceptable designs, furnish drawings, specifications, manufacturing techniques and other pertinent data to the Project Officer.

2.4 The above requirements were changed by the following supplemental agreements.

(1) Supplement Agreement No. 1 changed the period of the contract to run from August 5, 1953 to March 15, 1954.

(2) Supplemental Agreement No. 2 defined more accurately the "manual attachment" requirement, for the non-electric blasting cap.

(3) Supplemental Agreement No. 3, deleted the requirement for a monthly progress report covering the final month of the contract with the understanding that information which would normally be given in such a report would be included in the final report.

(4) Supplemental Agreement No. 4 extended the contract to July 15, 1954 and required that the blasting caps detonate cast TNT Blocks.

(5) Supplemental Agreement No. 5 set the base charge for the blasting caps at 13.5 grains and changed the waterproofing requirement to 100 psi hydrostatic pressure for 3 hours.

(6) Supplemental Agreement No. 6 extended the period of the contract to January 15, 1955.

(7) Supplemental Agreement No. 7 canged the official name from Olin Industries Inc. to Olin Mathieson Chemical Corporation.

(8) Supplemental Agreement No. 8 extended the period of the contract to April 15, 1955.

2.5 On October 17, 1955 Contract DA-23-072-ORD-579 was accepted. This replaced the previous contract with requirements that the work on the original contract be completed, that 700 additional live loaded and 300 inert loaded non-electric blasting caps, and 1,000 live loaded and 150 inert loaded electric blasting caps be furnished. This contract was

for the period from September 1, 1955 to February 29, 1956. It was later amended by Supplemental Agreement No. 1 which deleted the requirement for furnishing "specifications, notes on development type materials and bases for procurement". Because the design has been established and little development work remained to be done. This contract did not require monthly progress reports.

2.6 The original contract required detailed monthly progress reports and 16 such reports were issued. These reports covered work done from the 16th of one month through the 15gh of the following month, starting with August 16, 1953. Because work was curtailed the 8th, 9th, 10th, and 11th reports covering the period from March 16, 1954 through July 15, 1954 were issued in letter form.

3. DISCUSSION

3.1 The purpose of this contract was to develop a new electric and non-electric (fuse) blasting cap which would be used by the U. S. Army Corps of Engineers. From the "invitations to bid" issued prior to awarding this contract, it appeared that the Ordnance Corps, Picatinny Arsenal, desired that a method of packaging should be developed along with the blasting caps. The packaging contract was never awarded, although some of the blasting cap performance specifications required testing in such packages.

3.1.1 Several months elapsed from the time the bid was submitted until the contract was awarded. In the meantime the personnel normally assigned to this type of development work were engaged in a high priority program under another contract with Picatinny Arsenal. As a result the start of work on this contract was delayed two months, and Supplemental Agreement No. 1 was negotiated to allow for this delay.

3.1.2 The manual attachment requirement for the non-electric cap (See paragraph 2.2.2) was not clear to us, and an inquiry as to the Arsenal's interpretation of this resulted in Supplemental Agreement No. 2. This required the non-electric blasting cap design to be such that attachment to safety fuses and detonating cord could be accomplished by the usual commercial type crimping devices.

3.2 From our knowledge and background of commercial blasting caps preliminary designs were made. Because Lead Azide is the most efficient primary explosive which is readily available it was chosen for the initiator. Cyclonite was chosen for the base charge because of its proven qualities. Aluminum was chosen as the metal for the blasting cap shell because of its availability, ease of fabrication and proven compatibility. Normal lead styphnate was chosen as the igniter for the non-electric cap because of its proven qualities and because of its sensitivity to ignition. A typical commercial assembly of plastic coated wires cast into a sulphur plug to position and hold the ends so a noble metal bridge wire could be soldered in place, was chosen for the electric blasting cap

assembly. Vinyl insulation on the lead wires was first tried but later discarded in favor of ethyl cellulose because of its availability. The choice of the bridge wire was expected to be the relatively simple matter of choosing a diameter and composition which would give the required resistance and firing characteristics. These characteristics were dependent on the igniter chosen for the electric cap. The decision on the bridge wire was therefore withheld until the igniter was proven.

3.2.1 After the preliminary designs were carried as far as possible with proven components, four problems remained to be solved. They were:

(1) A method of retaining the igniter in the non-electric cap so that it would stand jolt, jumble, and transportation vibration tests.

(2) A (waterproof) seal for the electric blasting cap.

(3) An igniter for the electric cap and a bridge wire material to work with this igniter.

(4) The quantity of initiator and base charge to be used in both designs.

3.3 Three methods were considered for holding the igniter for the non-electric cap in place. They were:

(1) Making the igniter into a pellet, using a binding material if necessary, and locking this pellet in place by staking or crimping the case immediately above the top face of the pellet.

(2) Fastening the pressed charge in place with a small quantity of some compatible lacquer.

(3) Limiting the area of igniter exposed by using a perforated metal ferrule.

3.3.1 The first method was abandoned because of the cost and danger in making such pellets and because of the problem of staking or crimping in exactly the right spot. If the stake or crimp were too low it might explode the cap and if too high it would not hold the pellet firmly in place. Any method of assuring the right location for the crimp would be costly and not easily adapted to production loading.

3.3.2 The second proposed method was tried and worked quite well. However, the use of the lacquer could lead to misfires if too much were carelessly used. The problem of applying the correct amount, properly distributed over the face of the igniter and of drying the lacquer without causing an accumulation of many caps on the loading line, caused us to abandon this solution in favor of the third method.

3.3.3 The third method was adopted and is shown on the drawing of the non-electric design, page 56. The diameter of the center hole in the ferrule was chosen after jolt and jumble tests were run on assemblies with center holes of 1/8, 3/32, and 1/16 inch.

3.3.4 The specifications required that jolt and jumble tests be run with the caps in packages, but the packaging was not available. Therefore the tests were first run with no packaging. This proved too severe for all designs, including the lacquer seal. Sample caps were then put in a reasonable package consisting of a card board box with a thin felt liner. Jolt and jumble tests were again run on caps with a lacquered igniter, with no protection, and with 1/8, 3/32, and 1/16 inch center hole ferrules. Appreciable material broke loose on the caps with no protection. A slight amount of surface dust came loose on the caps containing the ferrule with the 1/8 inch hole. Some dusting was barely evident on the caps with ferrule having 3/32 and 1/16 inch holes and this only in the down vertical (most unfavorable) position. However, no additional material was lost in other positions, and there was no evidence of breaks on the face of the igniter. The caps fired satisfactorily after having been through the test. There was no loss of materials in the jumble

test. On the basis of this, a ferrule with a 3/32 inch center hole was chosen to anchor the igniter in place in the non-electric design. Using good safety fuses, several dozen caps of this design fired without a failure. Caps tested at high (125°F) and low (-65°F) temperatures and after six months storage, unpackaged, at 160°F all fired without a failure. Crimping the aluminum case onto a standard safety fuse, or detonating cord is easily accomplished with commercial blasting cap crimping tools.

3.3.5 Because temperature and humidity cycling and transportation vibration equipment were not then available, and because the packaging for the caps had not been designed, these tests were not run and will be performed at Picatinny Arsenal.

3.4 A waterproof seal for the electric cap presented a challenge. Twenty-two different sealing methods were tried ranging from foamed plastics, through epoxy adhesives to hot pitch. The most successful seal used a combination of a special crimp at the mouth of the blasting cap and a polysulphide rubber, compound which had the consistency of toothpaste which was forced into the assembly above the sulfur plug. The case was then crimped by a special crimping tool. This gave the assembly shown in the photograph on page 33. The assembly was then cured at 50°C over night.

3.4.1 To try the effectiveness of this seal the following tests were made. Ten samples tested at 25 psig water pressure for 4 hours did not leak. Ten more samples at 50 psig for 3 hours did not leak. Ten more samples at 100 psig for 3 hours did not leak. Ten more samples were given three temperature cycles from -40°F to 165°F then 100 psig water pressure for 3 hours. None leaked. Ten more were given two cycles at -40°F to 165°F, then a third cycle from -60°F to 170°F, then 150 psig for 3 hours. Again none of the ten samples leaked. Seventy-five samples more were assembled. They were placed in a -65°F cold box and brought down to that temperature, then placed in the water pressure chamber with the water at 32°F and put under 100 psig for 3 hours. Twenty-five were withdrawn and examined. None had leaked. The test cycle

was repeated, and twenty-five more withdrawn. Again none had leaked. On the third cycle the remaining 25 caps were reduced to -80°F then subjected to 100 psig for 3 hours in ice water. None of these caps leaked.

3.4.2 Seventy additional caps were loaded and sealed and subjected to 165°F for 30 days. They were then cycled from -60°F to 32°F three times and tested at 100 psig for 3 hours. About 50% leaked. Examination of those caps which leaked showed evidence of corrosion on the lead wires. The polysulphide rubber compound being used (EC-1120) PC made by Minnesota Mining and Manufacturing Co.) contained an ethylene dichloride solvent which apparently caused this corrosion. A different compound (EC-1120 by Minnesota Mining and Manufacturing Co.) which contained methyl ethyl ketone instead of ethylene dichloride was tried. One hundred ten samples sealed with EC-1120 and 110 samples sealed with EC-1120 PC were loaded and subjected to 165°F sotrage for 30 days. They were then reduced to -60°F and put in 32°F water under 25 psig pressure for four hours. One third of the caps were opened and none had leaked. The -60°F to 32°F and 25 psig pressure cycle was repeated. One half the remaining caps were removed and checked. One cap sealed with EC-1120 had leaked, but it was evident that insufficient sealant had been used. The cycle was repeated and the remaining caps were examined. Again one cap sealed with EC-1120 had leaked, but again the sealant had not filled the volume between the sulfur plug and the crimp. Also one cap sealed with EC-1120 PC had leaked and in all the caps sealed with this compound there was evidence of corrosion on the lead wires. As a result of this test EC-1120 was chosen as the sealant with the knowledge that great care must be exercised to assure that sufficient sealant is properly placed in the cap prior to crimping. Because it is a more sensitive indicator of moisture, caps for waterproofing tests were loaded with anhydrous copper sulphate instead of explosives.

3.4.4 Later in the program 300 electrical blasting caps were loaded and sealed with the EC-1120 sealant. These were intended for shipment to Picatinny Arsenal. Samples had been taken periodically during the loading and fired to test the loading procedure and assure that no unnoticed changes occurred. The firing tests

were made within a few hours of the time the sealant was placed. All such tests were satisfactory. When the blasting caps were all assembled, several samples were selected at random for quality control tests. These samples fired with very long reaction times or in some cases misfired completely. The cause was eventually traced to the Methy Ethyl Ketone in the EC 1120 sealant. This volatile solvent, whose value in the compound was simply to extend its "pot life," would gradually, after the case was crimped, seep down into the igniter, deadening it and thereby causing long firing times and misfired. The effect is not a permanent one because eventually the solvent is able to work its way out of the blasting cap. This was proven by the shortening of firing times when the caps were stored at 165°F for several weeks and by the fact that after 10 months of storage at ambient temperatures the firing times of the blasting caps adversely affected the MEK had returned almost to normal.

3.4.5 After discussing the problem with the Minnesota Mining and Manufacturing Co. (3M) representative, sealant EC 1130 with accelerator EC 1063 was tried. The EC-1130 contains liquid polysulphide, phenolic resin, stearic acid, zinc sulphide and barium sulphate. The EC 1063 contains lead dioxide, stearic acid and dibutylphthalate. None of these materials seemed likely to be incompatible. Test blasting caps were loaded and sealed and stored at 72°C. Samples were withdrawn and tested after 7 and 18 days. There was no change in performance between caps tested before storage and those tested after 7 and after 18 days storage. Twenty blasting caps sealed with tne new compound were tested as required by the specifications at 100 psig for 3 hours. All fired in the normal range of firing times. The only disadvantage of the new compound was its shorter "pot life," of about four hours. This was considered a minor drawback, so long as it produced adequate results.

3.4.6 The original specification required that the electric blasting cap withstand immersion in 25 feet of water for 4 hours without misfiring. From our experience with commercial blasting operations, this pressure

seemed low. In tamping a charged hole, pressures as much as 100 psig are sometimes reached. Therefore at our suggestion, a more stringent water pressure requirement was incorporated into the requirements as part of Supplemental Agreement No. 5 which specified 100 psig for 3 hours as the waterproofing test.

3.4.7 After our difficulties with the sealant were solved, a new method of placing the sealant was developed. This assured better placement of the proper amount of sealant. Prior to this development, the cup had been loaded with explosives, the sulfur plug put in place with the lead wires extending from the mouth of the cap. A grease gun fitted with a special nozzle, a thin walled tube about 1/16 inch in diameter and 1 inch long, was used to force the viscous sealant into the mouth of the cap and around the wires. The assembly was allowed to set for about 1 hour for the sealant to flow evenly into place and allow any air bubbles to escape. The cap was then crimped, giving the assembly shown in the photographs on page 33. This sealing process was a messy job. It was difficult to avoid trapping air under the sealant. It was hard to judge the proper amount of sealant used, and to keep it off the exposed wires. Any excess of sealant tended to foul the crimping tool and too little sealant produced poor seals. To improve this operation the crimp was redesigned to leave a small opening at the mouth of the case between the wires. The cases were crimped before adding the sealant and with the sulfur plugs positioned to the right depth. This held the wires in place while the sealant was being added. Drawings of the new crimping tool are reproduced on pages 34, 37, 38 and 40. Placing the sealant in the crimped case was done with equipment shown on page 42. The crimped blasting cap was pushed into the filling nozzle of this tool and held in place by a very light pull on the lead wires. The pluger on the top of the sealant reservoir was pushed down either by a hand operated arbor or hydraulic press. This forced the sealant out of the nozzle into the cap. When the cap filled with sealant the material would begin to appear around the lead wires and the nozzle. The pull on the lead wires was then released, and the cap filled completely and forced off the nozzle. This method of

placing the sealant worked faster and cleaner and assured an adequate amount of sealant properly placed. The resultant design is shown on the prints of the final drawings, page 57.

3.5 Finding a satisfactory igniter for the electric blasting cap was expected to be one of the most difficult problems in this program. Several good igniters are now in use in commercial caps but they are, in general, either patented or proprietary and therefore unavailable for use here. The requirements for a good igniter were not fully covered by the specifications for it would have been possible to meet the requirements and still have a poor igniter. For a group of blasting caps, wired in series as is the normal practice, to all fire reliably a proper relationship must exist between the length of time required to ignite and the time which elapses before the first cap in the series detonates and destroys the circuit. For discussion purposes the length of time necessary to apply current to the bridge wire to get ignition is called the pulse time. The time which elapses from the instant current is applied until the cap fires is called the total time. The difference between pulse time and total time is called lag time. In series firing if all blasting caps are to function properly, the longest pulse time of any cap in the series must be less than the shortest total time of any cap in the series. The goal for this program was an igniter whose lag time was 1 1/2 times its pulse time, and a total firing time between 5 and 15 milliseconds.

3.5.1 Testing various igniter materials for pulse and lag time was done with a pendulum timer and a chronograph. The pendulum timer is a device used by Olin Mathieson Chemical Corporation to test commercial caps. This device will deliver a preset amount of current for a predetermined length of time. The total time was measured by a standard commercial chronograph wired to start on the instant of current application and to stop when a thin copper wire, fastened across the base of the cap with Scotch tape, is broken. The set up of the blasting cap itself is shown in the photograph on page 28. In testing, blasting caps with base and initiator charges pressed in place have added to them the loose igniter being tested. The bridge wire, sulfur plug and lead wire assembly are put in the cap and a wooden applicator stick is

used to hold it firmly in place. A weight is placed on top of the applicator stick to assure consistent compaction of the igniter. The lead wires are connected to the pendulum timer and a break wire is fastened to the base of the cap and connected to the stop circuit of the chronograph. The cap is then ready for testing. This method gives accurate results and is quick and easy to set up.

3.5.2 A great many different materials and combinations of materials were considered. Twenty materials, combinations of materials, and variations of combinations were given extensive tests. Three possible mixtures were found which had desirable characteristics. A portion of the test results on these mixtures is included in pages 23 through 27 as an illustration. Mixture 8D was chosen as the igniter to be used and a slight adjustment of the three components was made to improve its firing characteristics. The final proportions used are:

18% Basic Lead Styphnate (Balcinol)
22% Barium Chromate
60% Blankfire Powder

A description of the method of preparing Balcinol, which is an amorphous colloidal basic lead styphnate is given on page 29. It is essentially the material covered by U. S. Patent No. 2020665, which expired November 12, 1952. The blankfire powder is a standard commercial product made by the Ball Powder Process and is the fine screenings (100% through a 62 mesh screen and caught on 150 mesh screen) discarded from the standard production product. The barium chromate conforms to Specification JAN-B-550 Class A and 100% passes a 325 mesh screen. The method for mixing these ingredients is given on page 31. In the course of experimentation and loading, several different lots were made to prove reproducibility.

3.5.3 The bridge wire chosen was 0.0095 inches in diameter and is 80% Platinum, 15% Rhodium, and 5% Ruthenium and has a resistance of 187 ohms per foot. It is a standard product of the Sigmund Cohn Company under their identifying No. 851Pt. In the length used, 0.0075", this gives a resistance, including both 12

feet lead wires, of 1.35 to 1.65 ohms. This bridge wire and the igniter chosen would not fire from 0.20 amperes of current for 5 seconds or five minutes for that matter. It did fire reliably at 0.45 amperes for 50 milliseconds and at temperatures from -65°F to 125°F. Reliable firings with acceptable times were obtained after limited storage (18 days) at 165°F. In actual series firing tests, 50 caps fired reliably from the output of a standard U. S. Army 10 cap blasting machine.

3.5.4 While loading the required 1000 electric caps for final shipment random samples were tested for production control.

	Firing Time Milliseconds	Lead Plate Hole Diameter, Inches
	12.62	.321
	10.88	.321
	10.68	.321
	10.56	.321
	11.94	.321
	12.08	.341
	9.24	.321
	10.68	.321
Average	11.09	

Twenty samples loaded at the end of production were tested for quality control.

	9.51	.341
	10.61	.321
	10.67	.321
	11.77	.301
	10.23	.321
	9.72	.341
	10.00	.321
	10.38	.321
	10.49	.321
	10.03	.321
	11.13	.341
	10.72	.321
	10.82	.321
	10.46	.321
	12.19	.301
	9.99	.321
	11.13	.321
	11.35	.321
	10.73	.321
	11.21	.301
Average	10.66	

3.6 Determining the required size of the base charge seemed to be a simple problem, but turned out to be one of the most time consuming tasks involved. The first test to determine the base charge size is given on pages 43, 44 and 45. Photographs of the test plates resulting from firing TNT using caps with various size base charges are included as pages 46, 47, 48 and 49. From this test, it was decided that a base charge of 7.5 - 8 grains of cyclonite with 3.1 - 4.1 grains of lead azide would reliably detonate the TNT blocks.

3.6.1 In discussing this with Arsenal personnel the question of the age of the TNT blocks was brought up. The blocks used in the tests were Lot No. KNK1-766 obtained from Kankakee Ordnance Works, Kankakee, Illinois, and had been in our magazines since 1947 or 1948. It was the opinion of the Arsenal that pressed TNT blocks after long storage took on the characteristics of cast TNT and they therefore asked the specifications be altered to require detonation of cast TNT blocks. This resulted in Supplemental Agreement No. 4. Cast TNT blocks were made and tested to determine the size of base charge required. It was shown that a base charge of 20 grains of cyclonite and 8 grains of lead azide initiator would not detonate a cast TNT block reliably. Caps with PETN and Tetryl base charges were no better than those with cyclonite. Base charges larger than 20 grains were out of the question because even these were too long to fit properly in the blasting cap cavity in the standard TNT block. After these test results the Arsenal requested that the blasting caps be made with 13.5 grain base charges, which is the maximum size that can be loaded in a cap of the required diameter and still have a cap short enough to fit the TNT blocks. It is also appreciably larger than the standard commercial blasting caps which means that most manufacturers to produce these caps will have to work with smaller quantities. This will increase production costs. Specifying the base charge as 13.5 grains was done by Supplemental Agreement No. 5.

3.6.2 The Arsenal was still anxious to determine if pressed TNT would take on the characteristics of cast TNT so a six months accelerated aging test

was arranged. A number of pressed TNT blocks were placed in a specially barricaded storage oven set at 150°F. A number of non-electric caps were also stored in the oven. A temperature recorder was used to determine the actual temperatures obtained. It was planned that each month for a 6 month period pressed TNT blocks and non-electric blasting caps would be taken from storage and tested. Supplemental Agreement No. 6 was negotiated to allow time and money for this added test. The results of tests made after the first month's storage are given on page 50. Photographs of the test plates and the appearance of the blocks are shown on pages 52 and 55. It was indicated in this first test that a change was taking place. Tests in subsequent months proved it. At the end of the fifth month the inside of the oven had become so coated with TNT crystals and the TNT blocks had deteriorated to such a degree that, in the interest of safety and because the results of the test were apparent, the Arsenal was asked for permission to stop the test. This permission was granted. Photographs of the interior of the oven and the TNT blocks are included as pages 53 and 54 of the appendix. It appeared that the inner portion of the blocks vaporized and passed through the cardboard walls of the block containers and crystallized on the cooler walls of the oven. It is interesting to note that the TNT did not melt and run out of the container.

3.7 After the base charge was established at 13.5 grains, designs of the electric and non-electric caps were submitted to the Arsenal on June 23, 1954 for approval as required by the specifications. Subject to a few minor changes such as a slight flare on the mouth of the case, the design of non-electric cap was accepted on October 13, 1954. Approval of the electric blasting cap design was withheld because of lack of compatibility data on the igniter mixture. Two alternate igniter mixtures were suggested. One contained Diazodinitrophenol which is incompatible with Lead Azide and the other contained Lead Thiocyanate which is incompatible with aluminum. It was impractical to change the material in the blasting cap shell to

copper as this metal is not compatible with Lead Azide. It was pointed out that each of the three components in the igniter mixture had been used many times in Ordnance items and were, therefore, probably satisfactory even though they had not been used in this combination before. The Arsenal agreed to accept the electric blasting cap design and Supplemental Agreement No. 8 was made to extend the delivery date.

3.7.1 When the decision was given to use a 13.5 grain base charge, longer cases had to be ordered. Loading of the non-electric caps was held up until the electric cap design was approved. This was done because the caps are the same length and the base and initiator charges are identical and a savings could be realized by loading them at the same time. Loading was started in February of 1955 and 300 non-electric caps were shipped on March 18, 1955. The difficulty of the sealant deadening the igniter mix described in paragraph 3.4.4 was encountered. An extension of the contract was necessary to solve this problem. The Arsenal chose to issue a new contract instead and the present contract resulted which required completion of the earlier contract and furnished 700 additional live and 300 inert loaded non-electric blasting caps, now designated as T-7, and 1,000 live and 150 inert loaded electric blasting caps, now designated T-6. The required non-electric blasting caps were shipped in November 1955, included the inert units which were loaded with sugar. The increased order made it necessary to order additional cases so loading the electric caps was held up. These were loaded and were shipped on March 1, 1956. The inert loaded units were also loaded with sugar in this instance. Test results on control samples of this shipment are given in paragraph 3.5.4 above. In this report a summary of the work done on this contract has been given. Many minor details have been either passed over lightly or left out completely. Further detail on these points may be found in the Monthly Progress Reports covering the period from August 15, 1953 through December 15, 1954.

4.0 CONCLUSIONS

Designs for both the electric and non-electric blasting cap have been developed under these contracts. The designs do not depart greatly from commercial standards, and any commercial producer of blasting caps can, without undue difficulty load these caps. Because of their size and particular requirements they will be more costly than commercial caps, but not unduly so. The igniter for the electric cap will permit series firing without difficulty.

5. APPENDIX

5.1 Igniter Mix Evaluation

5.1.1 The igniters were tested in a 0.252" I.D. case containing: 5.3-6.0 grains of Cyclonite, 2.9-3.8 grains of Dextrinated Lead Azide, a 1/8" column of the igniter being tested, a sulphur plug with a noble metal bridge wire 1.1 mils in diameter 0.115" long and a resistance of 450 ohms per yard and 22 gage tinned copper lead wire with plastic insulation. The test set is as pictured on Page 28 in this appendix. The procedure used is given on Page 16 of this report. 0.625 pounds of weight was used on the applicator stick and the test current was 1.0 amperes. The following mixtures were tested. The identifying numbers are those used in actual tests:

Mixture 2D

Blank-Fire Powder	31%
Potassium Chlorate	31%
Lead Dinitrosoresorcinate	31%
Barium Chromate	7%

Mixture 8D

Blank-Fire Powder	55%
Balcinol (Collodial Basic Lead Styphnate)	15%
Barium Chromate	30%

Mixture 10B

Lead Dinitroresorcinate	40%
Potassium Chlorate	50%
Barium Chromate	10%

5.1.2 Table 1

Mix 2D (Weight of 1/8" column - 0.046 grams)

Sample	1	2	3	4	5	Avg.	Min.	Max.
Pulse	4.0	3.5	3.5	4.5	4.0	3.9	3.5	4.5
Lag	7.2	7.8	10.0	10.5	18.9	10.9	7.2	18.9
Total	11.2	11.3	13.5	15.0	22.9	14.8	11.2	22.9

Mix 8D (Weight of 1/8" column - 0.050 grams)

Sample	1	2	3	4	5	Avg.	Min.	Max.
Pulse	5.5	5.5	4.5	5.5	4.5	5.1	4.5	5.5
Lag	13.3	14.7	16.4	11.2	9.6	13.0	9.6	16.4
Total	18.8	20.2	20.9	16.7	14.1	18.1	14.1	20.9

Mix 10B (Weight of 1/8" column - 0.114 grams)

Sample	1	2	3	4	5	Avg.	Min.	Max.
Pulse	3.5	4.5	3.5	4.0	3.5	3.8	3.5	4.5
Lag	4.6	7.5	4.9	4.1	3.5	4.9	3.5	7.5
Total	8.1	12.0	8.4	8.1	7.0	8.7	7.0	12.0

5.1.3 Table 2

Test conditions same as above except a 1.875 lb. weight is used on the applicator stick.

Mix 2D

Sample	1	2	3	4	5	Avg.	Min.	Max.
Pulse	3.5	3.5	3.5	4.0	3.5	3.6	3.5	4.0
Lag	4.9	3.9	4.5	5.2	4.2	4.5	3.9	5.2
Total	8.4	7.4	8.0	9.2	7.7	8.1	7.4	9.2

Mix 8D

Sample	1	2	3	4	5	Avg.	Min.	Max.
Pulse	5.5	5.0	4.0	5.0	5.0	4.8	4.0	5.5
Lag	19.2	11.5	10.0	15.3	10.5	13.3	10.0	19.2
Total	24.7	16.5	14.0	20.3	15.5	18.1	14.0	24.7

Mix 10B

Sample	1	2	3	4	5	Avg.	Min.	Max.
Pulse	3.5	4.0	3.5	4.0	3.5	3.7	3.5	4.0
Lag	2.0	8.6	4.1	7.9	2.6	5.1	2.0	8.6
Total	5.5	12.6	7.6	11.9	6.1	8.8	5.5	12.6

5.1.4 Table 3

Same conditions as for Table 1. Test repeated to prove uniformity.

Mix 2D

Sample	1	2	3	4	5	Avg.	Min.	Max.
Pulse	4.5	4.0	4.0	4.0	4.0	4.1	4.0	4.5
Lag	7.2	24.6	11.0	5.7	6.5	11.0	5.7	24.6
Total	11.7	28.6	15.0	9.7	10.5	15.1	9.7	28.6

Mix 8D

Sample	1	2	3	4	5	Avg.	Min.	Max.
Pulse	3.0	4.5	3.5	4.5	5.5	4.2	3.0	5.5
Lag	9.0	12.8	15.0	13.8	16.6	13.4	9.0	16.6
Total	12.0	17.3	18.5	18.3	22.1	17.6	12.0	22.1

Mix 10B

Sample	1	2	3	4	5	Avg.	Min.	Max.
Pulse	3.5	4.5	3.5	4.0	3.5	3.8	3.5	4.5
Lag	4.6	7.5	4.9	4.1	3.5	4.9	3.5	7.5
Total	8.1	12.0	8.4	8.1	7.0	8.7	7.0	12.0

5.1.5 Table 4

Conditions as in Table 1 except that the required 0.215" I.D. cap was used with the bridge wire selected for this design (0.95 mil dia., 187 ohms per foot and 0.075" long). 1/8" column weight changes because of smaller I.D.

Mix 2D (Weight of 1/8" column - 0.066 grams)

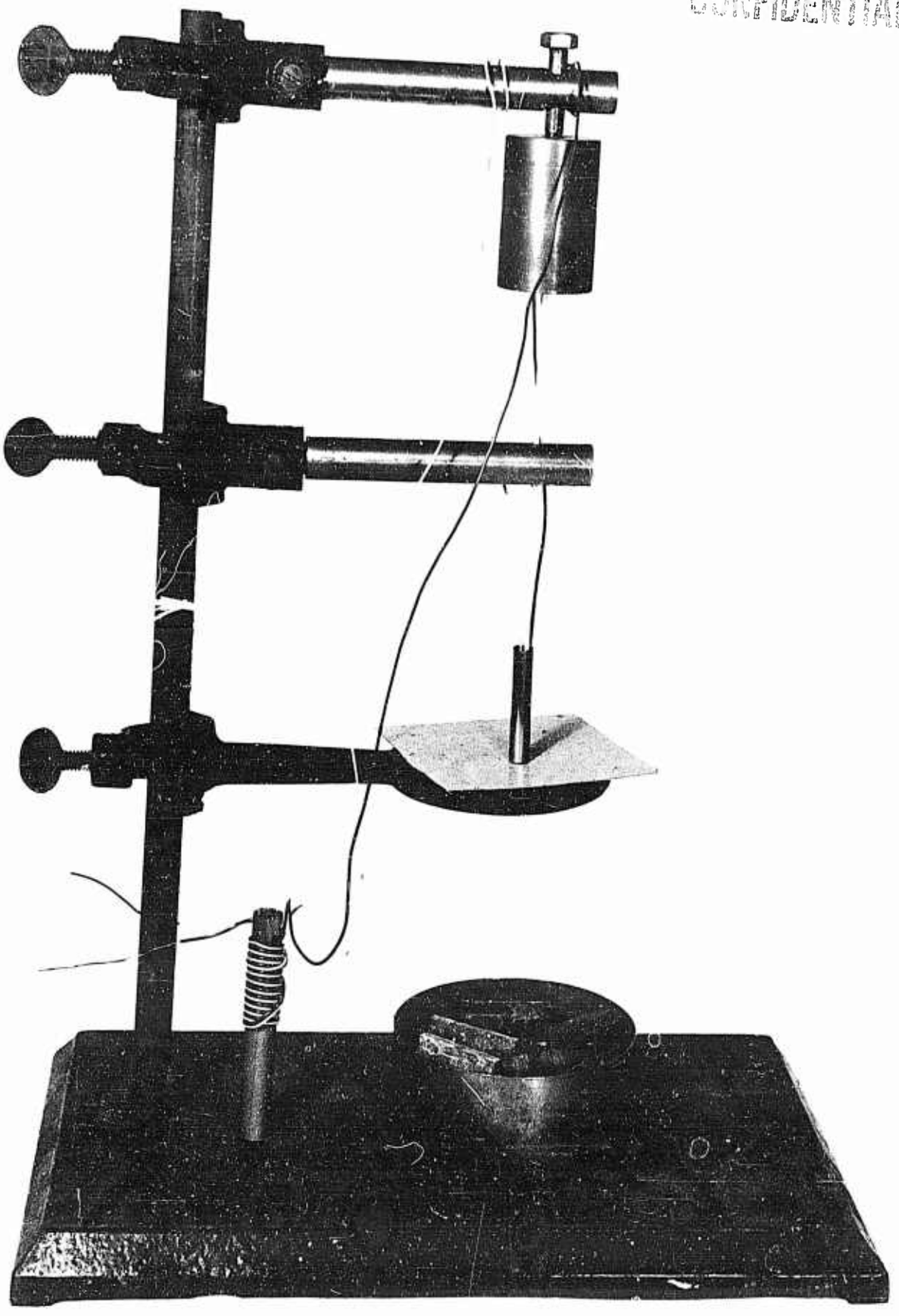
Sample	1	2	3	4	5	Avg.	Min.	Max.
Pulse	4.0	3.0	2.5	2.5	2.5	2.9	2.5	4.0
Lag	3.2	5.5	5.2	4.8	3.6	4.4	3.2	5.5
Total	7.2	8.5	7.7	7.3	6.1	7.3	6.1	8.5

Mix 8D (Weight of 1/8" column - 0.040 grams)

Sample	1	2	3	4	5	Avg.	Min.	Max.
Pulse	2.5	4.5	2.5	3.5	3.5	3.3	2.5	4.5
Lag	8.9	7.2	13.8	12.1	7.9	10.0	7.2	13.8
Total	11.4	11.7	16.3	15.6	11.4	13.3	11.4	16.3

Mix 10B (Weight of 1/8" column - 0.099 grams)

Sample	1	2	3	4	5	Avg.	Min.	Max.
Pulse	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Lag	3.1	3.1	3.6	2.9	4.3	3.4	2.9	4.3
Total	5.6	5.6	6.1	5.4	6.8	5.9	5.4	6.8



5.2 Igniter Test Fixture

5.3 LABORATORY PROCEDURE FOR BALCINOL PREPARATION

Equipment: Waterbath
Electric mixer
Assorted glassware.

Material: Trinitroresorcinol
Magnesium Oxide
26° BE Ammonium Hydroxide
Lead Nitrate Solution.

Procedure: Suspend 5 grams of trinitroresorcinol and .825 grams Magnesium Oxide in 175 cc of distilled water heated to 55°C in the waterbath. Start the mixer immediately after adding the TNR and Magnesium Oxide and continue until finished. Add 8 cc 26° BE Ammonium Hydroxide. Wait for 1 minute. Add 42.4 cc of Lead Nitrate Solution (342 grams per liter) drop by drop over a period of 2 minutes. Continue stirring for 2 or 3 minutes after adding the Lead Nitrate solution.

The solution should be allowed to cool to room temperature. The Balcinol will then settle to the bottom of the beaker. Decant the water and wash the residue with distilled water and allow the solids to settle again. Continue washing by decanting until a neutral solution (pH7) is obtained.

If the Ammonium Hydroxide is of insufficient concentration or if too much evaporates during the mixing operation a different and undesirable crystal form results which is difficult to work with and is extremely sensitive. Under microscopic examination, in slurry form, this material is made up of long very thin crystals, best described as "brush heap" crystals. The desirable Balcinol is extremely fine and uniform. No true crystalline structure is evident even at magnifications as high as 430 times. Large particles, if present are agglomerates of the very fine material. Because some crystal growth might occur after long storage under water, Balcinol is prepared

fresh for each use. True Balcinol is apparently very safe in water storage. It usually settles to a slurry containing 80 to 90% water.

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5.4

PREPARATION OF ELECTRIC BLASTING CAP IGNITER MIX

Equipment:

Laboratory balance
Flat smooth brass plate
Hard rubber spatula
Assorted glassware
Set of standard screens
Heavy glass front barricade
Long round hard wood roller.

Material:

60% Blank-Fire fines - Screened through a 0.62 onto a 150 mesh screen.
22% Barium Chromate - JAN-B-550 Class A - Screened through 325 mesh.
18% Balcinol Amorphous - As prepared in instructions Basic Lead Styphnate on Page 29.

Procedure:

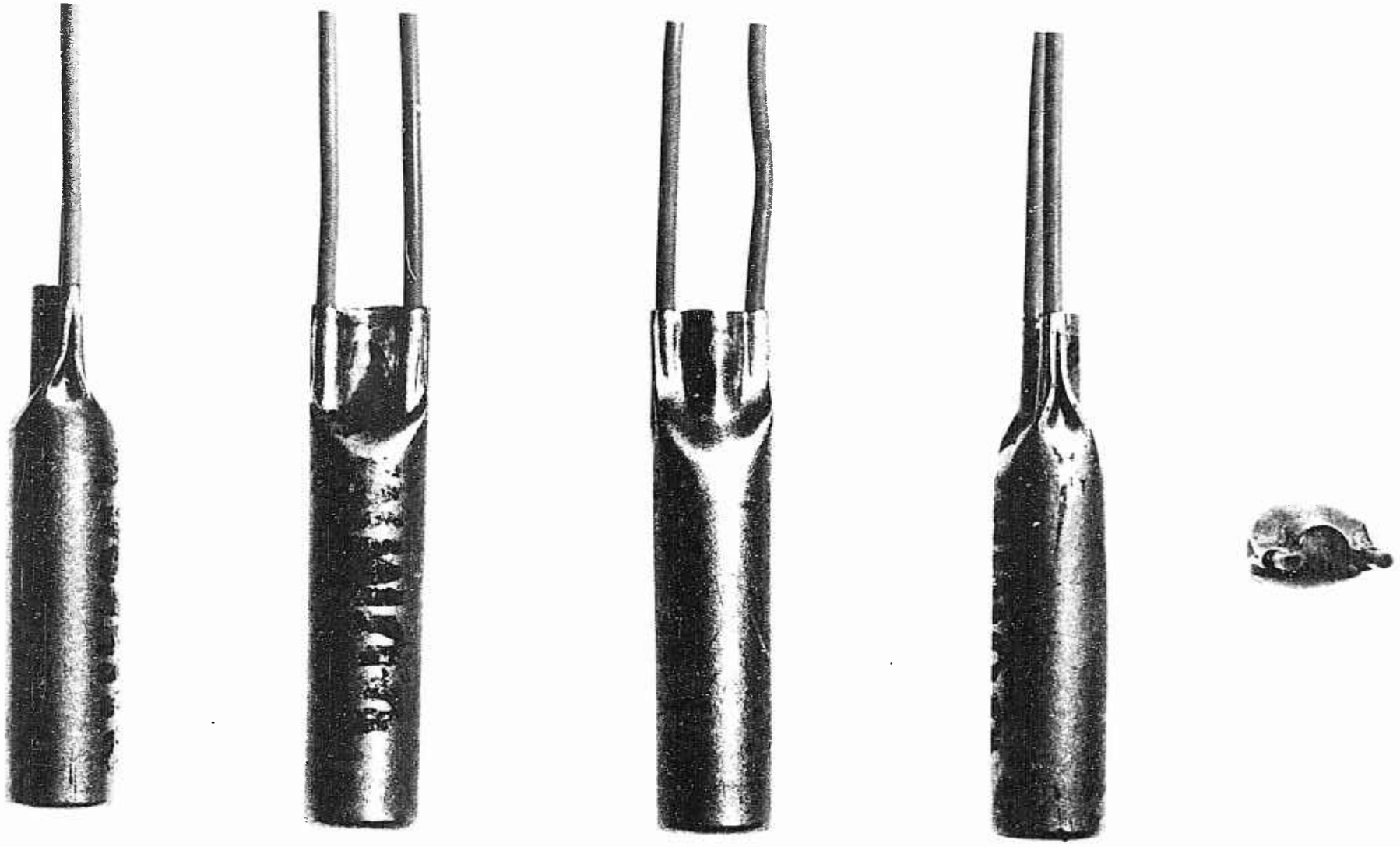
The water above the settled Balcinol is decanted and the Balcinol is stirred carefully but throughly. A sample of the slurry is taken, weighed and dried. A solids content is figured (usually 10 to 20 per cent). The wet Balcinol necessary to produce the desired quantity of final mix is weighed into a container and to it is added the proper amount of Barium Chromate. These are mixed together behind a barricade and additional water is added as needed so that a smooth, easily blended paste is formed. To this paste, the necessary amount of Blank-Fire powder is added. Water is again added as needed to maintain an easily blended paste. When the three ingredients are well blended, small quantities are taken from the container and put on the flat brass plate behind a barricade. Using the rubber spatula the small quantities are mixed intensively using a folding and smoothing action until there is no doubt of a homogenious mixture. Water is added as needed. The small quantities of the mixture are placed separately in flat polyethylene lined trays and dried at 50°C. When the lumps of mixture have dried to a point where

they are still easy to break, they are removed one at a time from the drying areas and placed on the flat brass plate. They are crushed with a rolling action using the long hard wood roller. After crushing the lumps, the mixture is screened through a #50 screen and onto a #140 screen. Material which does not pass the #50 screen is recrushed, that which passes the #140 screen is scrapped and that which is retained on the #140 screen is used.

All mixing and crushing operations are done from behind a barricade with the operator wearing fire-proof clothes, a face shield, and clean asbestos or right fitting leather gloves.

Failure to blend the mixture adequately results in erratic firing times or even an occasional mis-fire.

Larger scale mixing is done by a Sigma Intensive Mixer running for one hour.



5.5 Preliminary Electric Blasting Cap Design

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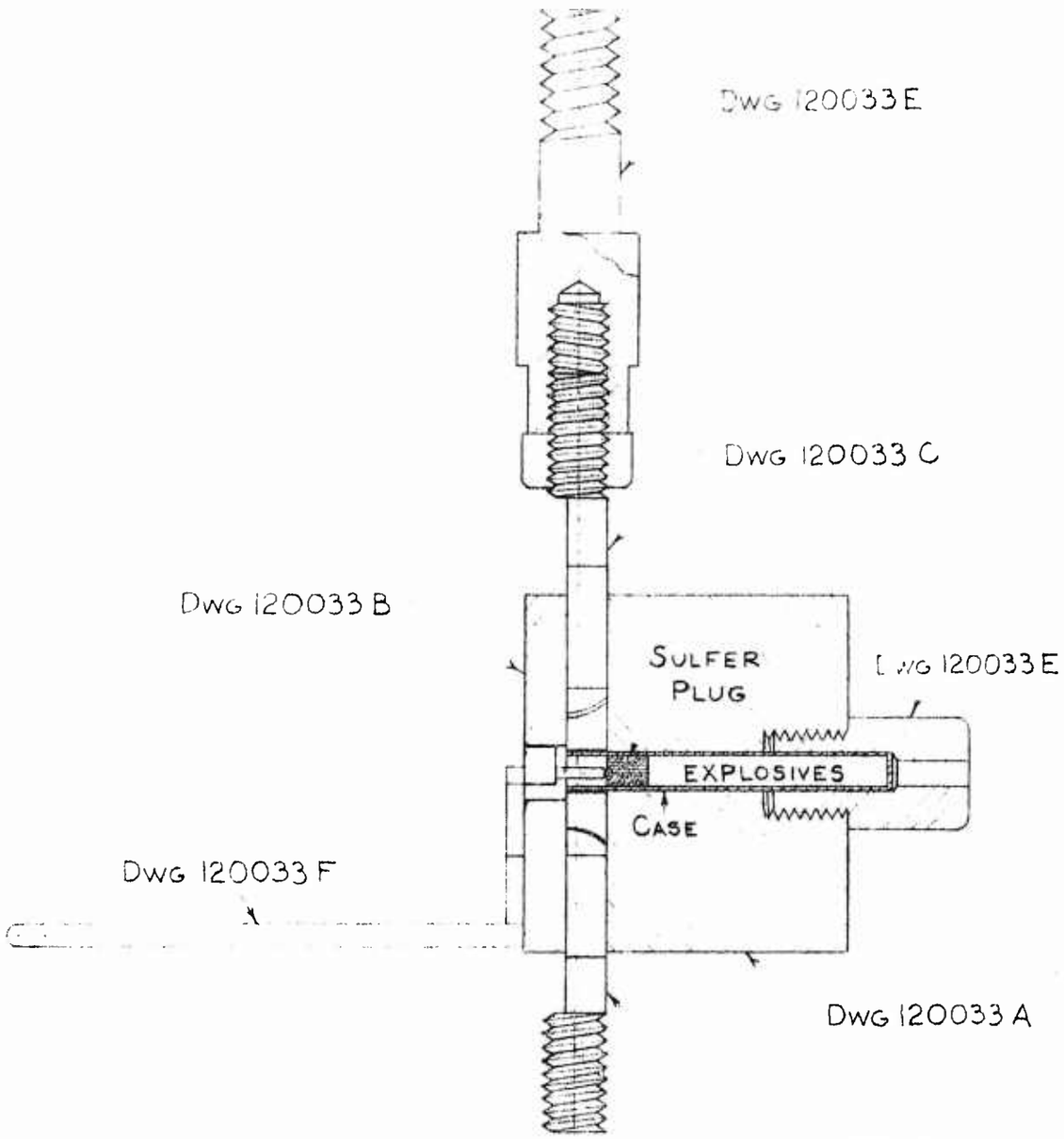

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EXPLOSIVES DIVISION
RESEARCH AND DEVELOPMENT DEPARTMENT
EAST ALTON, ILLINOIS

PART: CRIMPING FIXTURE FOR ELECTRIC BLASTING CAP ~ ASSEMBLY

SHEET 1 OF 1
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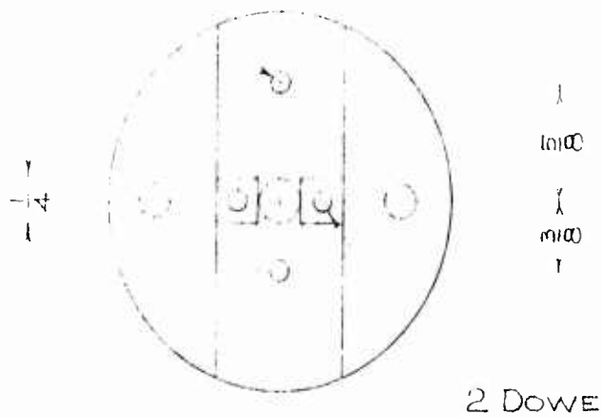
2 DOWEL PINS-$\frac{1}{8}$ DIA-PRESS FIT



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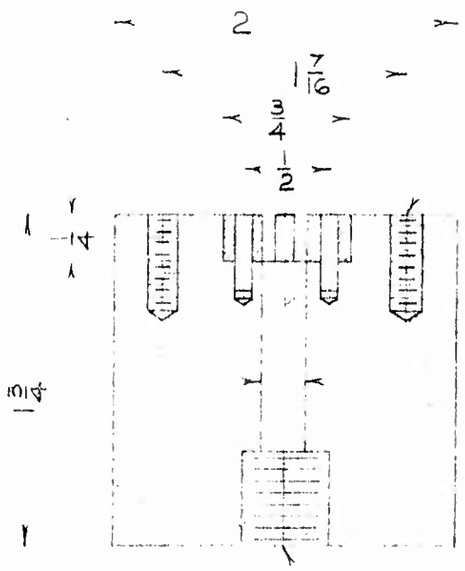

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.2410-.0005

$\frac{1}{2}$-20-NF, $\frac{1}{2}$ DEEP

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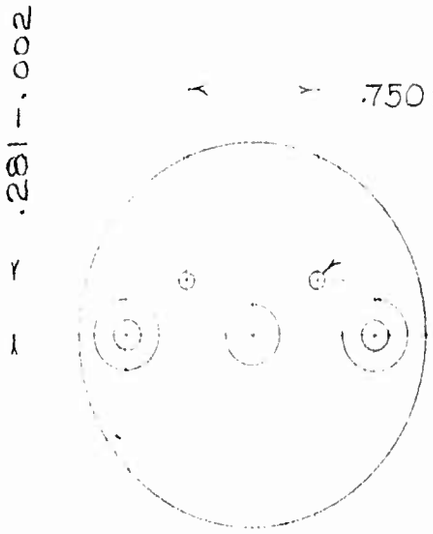

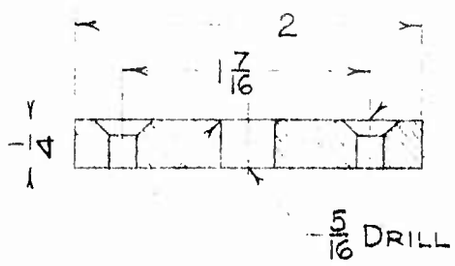

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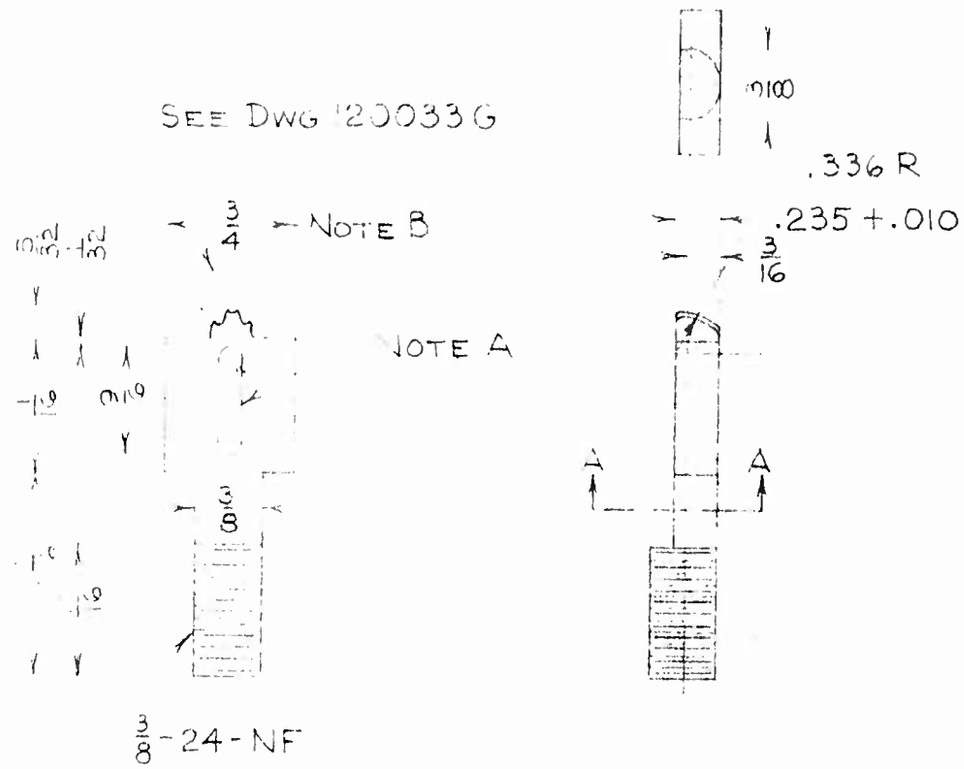
SECTION A-A



NOTES:

A - 1/8 DIA PIN MUST BE SLIDING FIT IN THIS SLOT.

B - MUST BE SLIDING FIT IN 3/4 SLOT OF DETAIL A.

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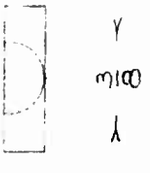
NOTES:

A- $\frac{1}{8}$ DIA PIN MUST BE SLIDING FIT IN THIS SLOT.

B- MUST BE SLIDING FIT IN $\frac{3}{4}$ SLOT OF DETAIL A.

SECTION A-A



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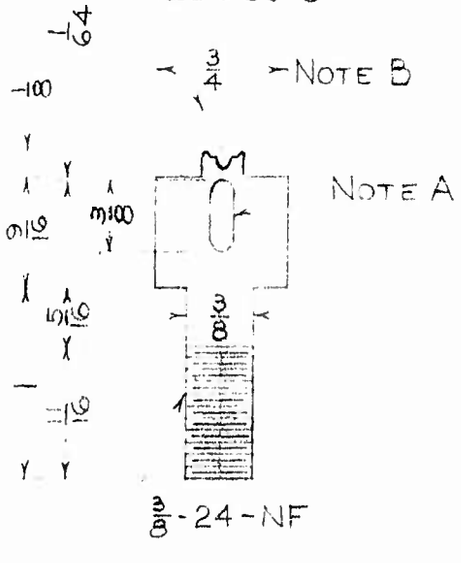

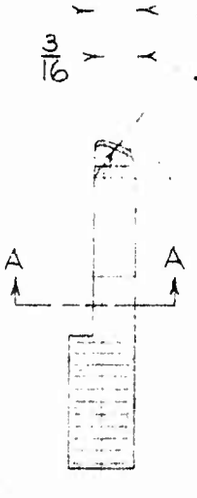

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APPROVED: J. H. Leary	DATE: 5 Apr 56	PART: CRIMPING FIXTURE FOR ELECTRIC BLASTING CAP - DETAIL "D"
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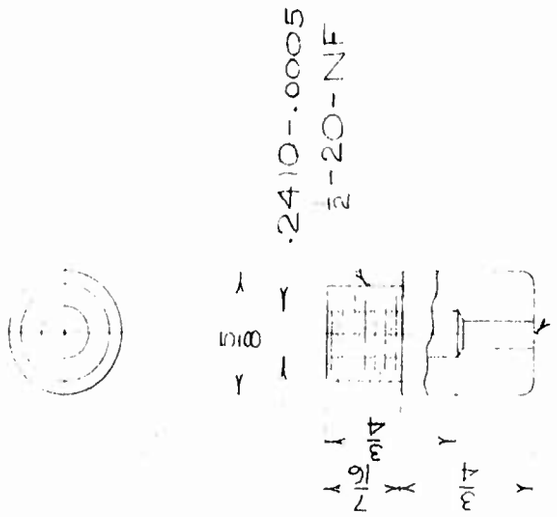

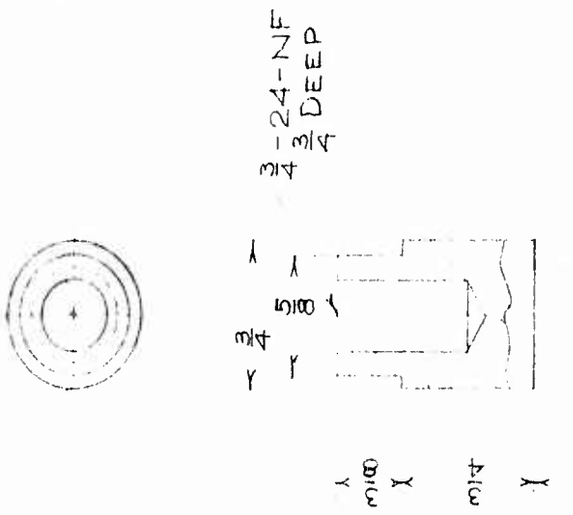

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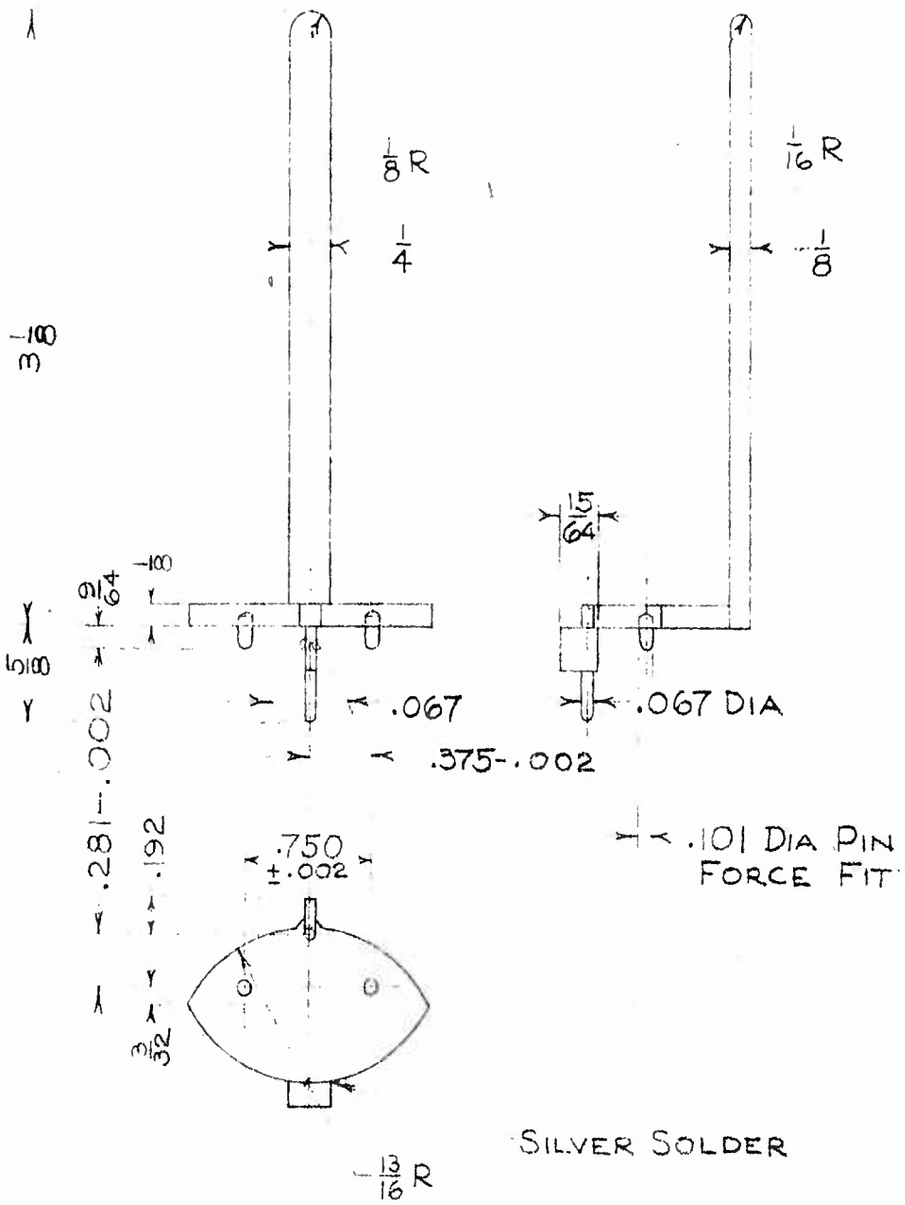

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DRAWN: VAN TRUMP	DATE: 2 APR 56	OLIN MATHIESON CHEMICAL CORPORATION EXPLOSIVES DIVISION RESEARCH AND DEVELOPMENT DEPARTMENT EAST ALTON, ILLINOIS
CHECKED: L E Smith	DATE: 5 Apr 56	
APPROVED: [signature]	DATE: 5 Apr. 56	PART: CRIMPING FIXTURE FOR ELECTRIC BLASTING CAP ~ DETAIL "G"
MATERIAL: COLD ROLLED STEEL	SUPERSEDES:	
TOLERANCES, UNLESS OTHERWISE SPECIFIED:		ASSEMBLY: DWG 120033
BREAK ALL SHARP EDGES DO NOT SCALE DRAWING—WORK TO FIGURES		SCALE: INCHES : 1=1
		SHEET 1 OF 1 A-120033F

SERVICE BLUE PRINT CO., ST. LOUIS, MO. 17TH 250 3-56

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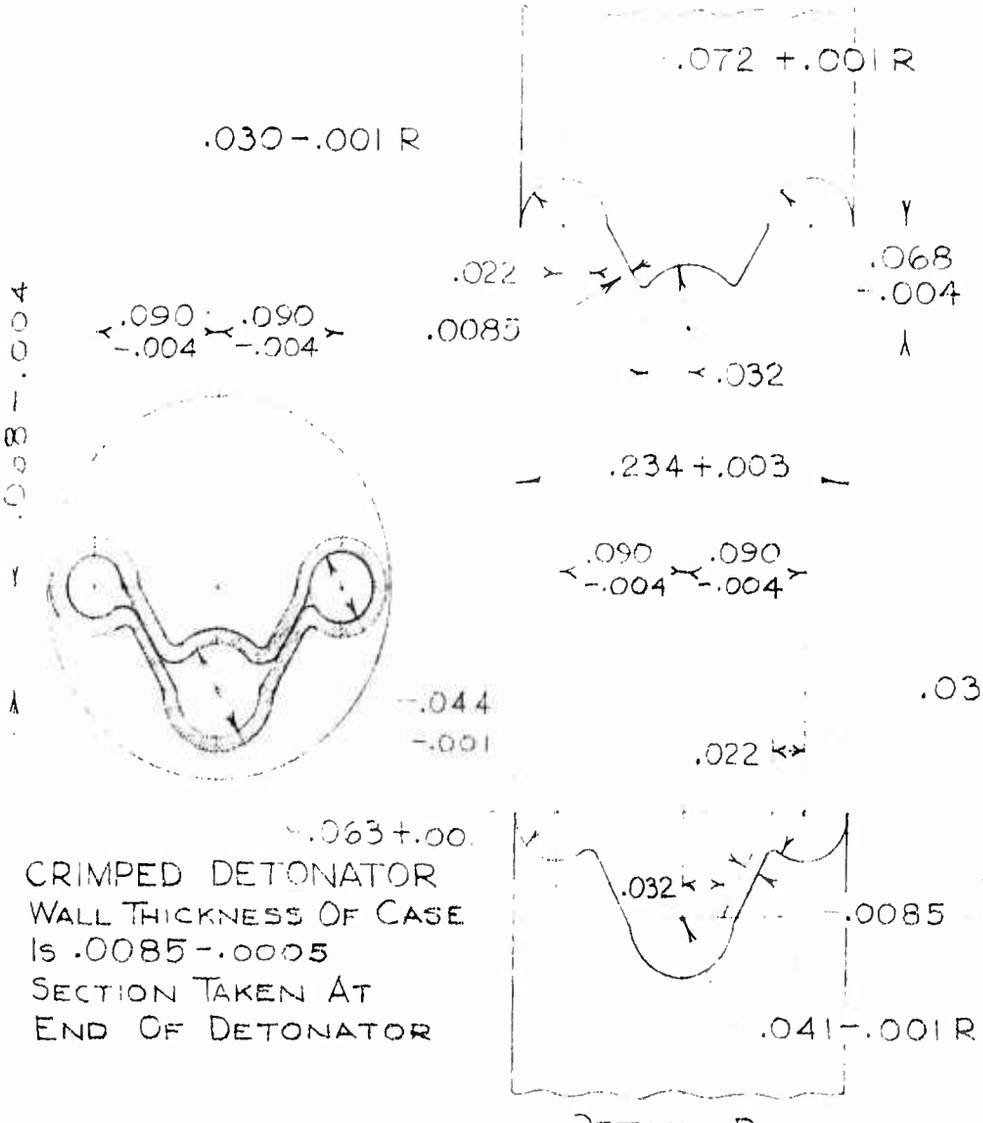
EA-619

A-120033 G

DETAIL C



CRIMPED DETONATOR
WALL THICKNESS OF CASE
IS .0085 -.0005
SECTION TAKEN AT
END OF DETONATOR

DETAIL D

NOTE:
PARTS MUST MATE TO PRODUCE CRIMPED DETONATOR
AS SHOWN.

CONFIDENTIAL

DRAWN: VAN TRUMP	DATE: 3 APR 56	OLIN MATHIESON CHEMICAL CORPORATION EXPLOSIVES DIVISION RESEARCH AND DEVELOPMENT DEPARTMENT EAST ALTON, ILLINOIS
CHECKED: L. E. Smith	DATE: 5 Apr 56	
APPROVED: [signature]	DATE: 5 Apr. '56	PART: CRIMPING FIXTURE FOR ELECTRIC BLASTING CAP ~ DETAILS "C & "D"
MATERIAL: COLD ROLLED STEEL	SUPERSEDES:	
TOLERANCES, UNLESS OTHERWISE SPECIFIED:		ASSEMBLY: DWG 120033
BREAK ALL SHARP EDGES DO NOT SCALE DRAWING — WORK TO FIGURES		SCALE: INCHES : 7=1
		SHEET 1 OF 1 A-120033 G

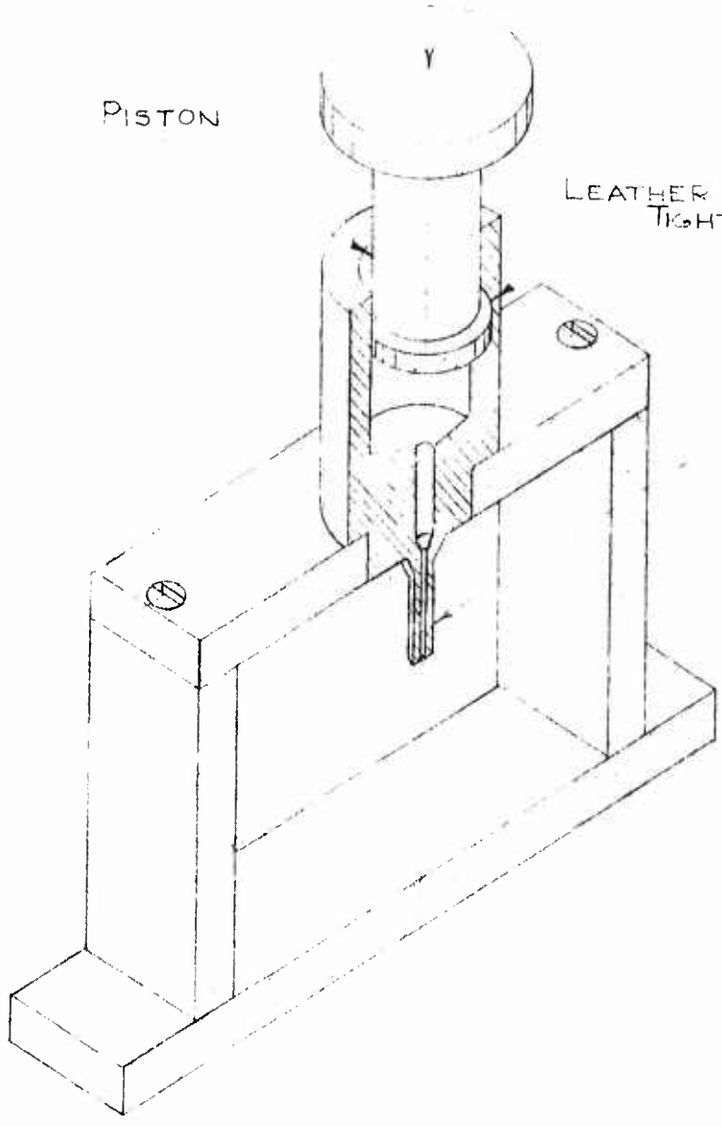
SERVICE BLUE PRINT CO., ST. LOUIS, MO. 17TH 250 3-56

EA-619

CONFIDENTIAL

42.

PRESSURE APPLIED HERE BY
HYDRAULIC OR HAND OPERATED PRESS



CONFIDENTIAL

DRAWN: VAN TRUMP	DATE: 5 APR 56	OLIN MATHIESON CHEMICAL CORPORATION EXPLOSIVES DIVISION RESEARCH AND DEVELOPMENT DEPARTMENT EAST ALTON, ILLINOIS
CHECKED: L.E. Smith	DATE: 5 Apr 56	
APPROVED: F.K. SEAVEY	DATE: 5 Apr '56	
MATERIAL:	SUPERSEDES:	PART: SEALING MATERIAL INJECTOR
TOLERANCES, UNLESS OTHERWISE SPECIFIED:		ASSEMBLY:
BREAK ALL SHARP EDGES DO NOT SCALE DRAWING -- WORK TO FIGURES		SCALE: SCHEMATIC
		SHEET 1 OF 1 A-130012

SERVICE BLUE PRINT CO ST. LOUIS, MO 177H 250 3-56

5.7 Base Charge Test-Data Sheet

Determination of minimum base charge required to detonate a 1/2 pound TNT Block at high order.

JAN-T-234

Test Specimens and Conditions:

1. 30 aluminum fuse caps were loaded (production WCCO Big Inch Caps - 0.232" OD x 0.220 ID x 1.15" long.)

2. The load pressure used to press the charges was a nominal 4,000 psi. - 140 pound dead load on a 0.213" diameter flat press pin.

3. The fuse caps were crimped to one foot lengths of black powder safety fuse.

4. The caps were inserted 1 1/2" into the bore of the 1/2 pound TNT Block, except No. 3 cap which was placed all the way into the bore of the block.

5. The 1/2 pound TNT Blocks were detonated on a 4" x 4" x 1/2" hot rolled steel black plates.

Cap No.	Base Charge Cyclonite Grains	Initiator Lead Azide Grains	Priming Styphnate Grains	Base Charge Pressed In Increments	Detonation of 1/2 pound TNT Block		
					Smoke	**Steel Plate Surface	Order
1	3	3	1	1	White	No Indentation	Low
2	3	3	1	1	White	No Indentation	
3/	3	3	1	1	Black	Indent 1/4" deep	High
4	4	3	1	2	Black	1 x 1" hole	High
5	4	3	1	2	Black	3/4 x 3/4	High
6	4	3	1	2	Black	1 x 1	High
7	5	3	1	2	Black	1 1/8 x 1 1/8	High
8	5	3	1	2	Black	1 1/8 x 1 1/3	High
9	5	3	1	2	Black	1 1/8 x 1 1/3	High
10	6	3	1	3	Black	1 1/4 x 1 1/4	High
11	6	3	1	3	Black	1 1/8 x 1 1/8	High
12	6	3	1	3	Black	1 3/8 x 1 3/8	High
13	7	4	1	3	Black	1 1/4 x 1 1/4	High
14	7	4	1	3	Black	1 1/8 x 1 1/8	High
15	7	4	1	3	Black	1 1/8 x 1 1/8	High
16	8	4	1	3	Black	1 5/8 x 1 5/8	High
17	8	4	1	3	Black	1 1/8 x 1 1/8	High

Cap No.	Base Charge Cyclonite Grains	Initiator Lead Azide Grains	Priming Styphnate Grains	Base Charge Pressed In Increments	Detonation of 1/2 pound TNT Block		
					Smoke	**Steel Plate Surface	Order
18	8	4	1	3	Black	1 1/8 x 1 1/8	High
*							
31	WCCO Fuse Cap used for Check Purposes				Black	3/4 x 3/4	High
32	WCCO Fuse Cap used for Check Purposes				Black	1 x 1	High

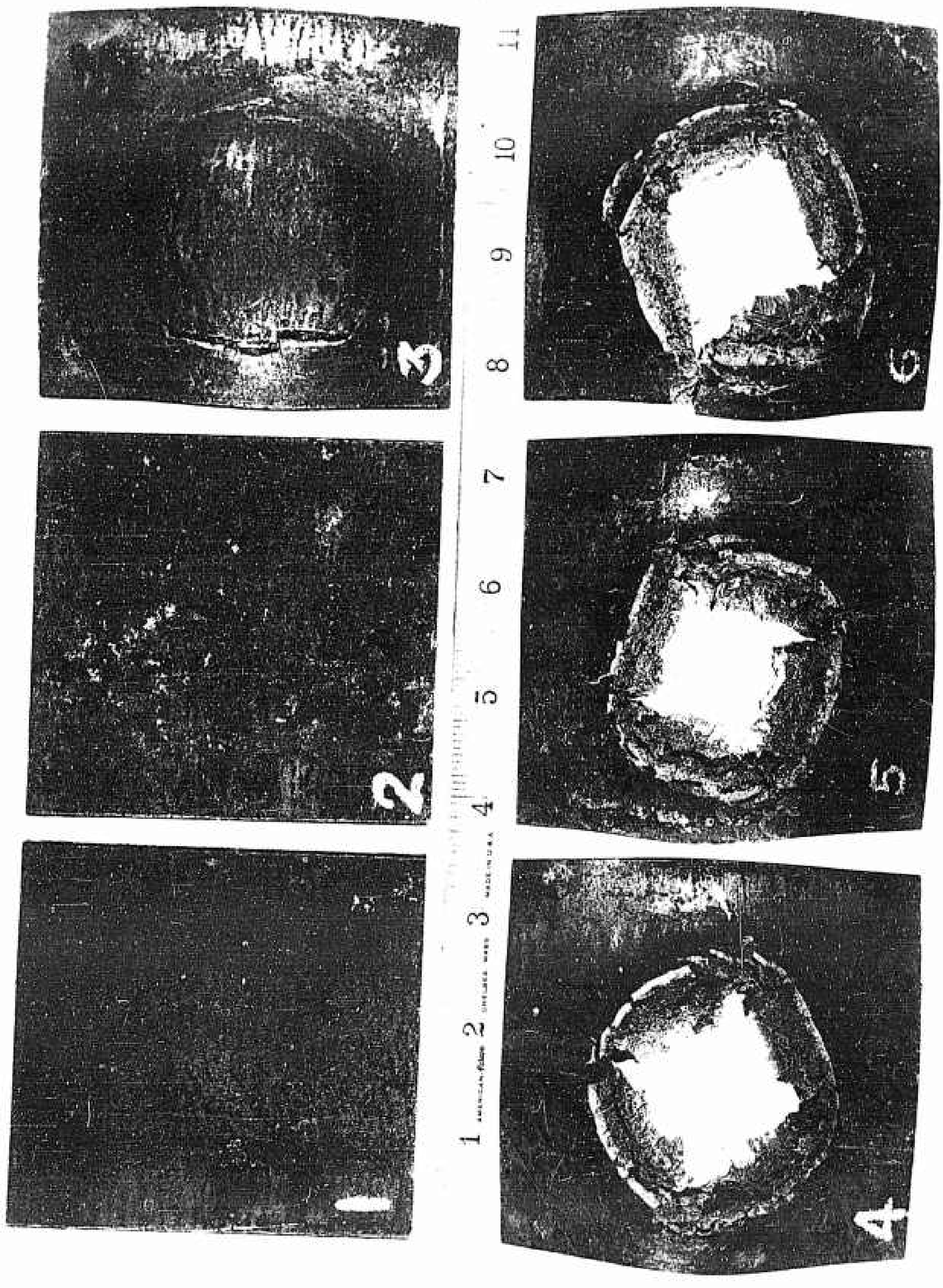
*-Caps 19 through 30 were not tested when it was noted maximum high order detonation was reached with Cap Nos. 7, 8, and 9.

/ Cap was placed all the way into the bore of 1/2 pound TNT block.

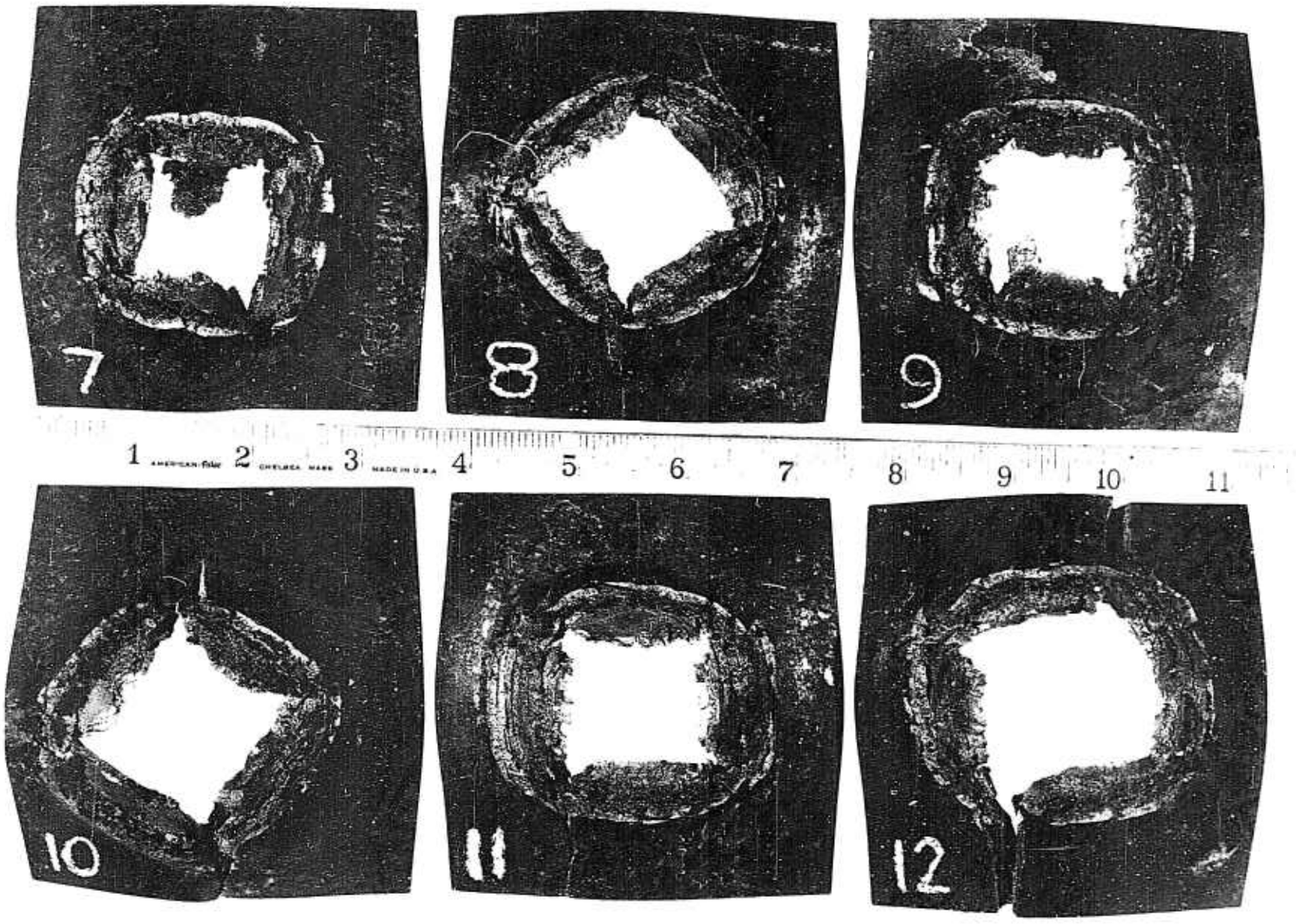
**See the photographs of the 4 x 4 x 1/2 inch hot rolled steel test plates, on pages __, __, and __ of this report.

CONCLUSIONS

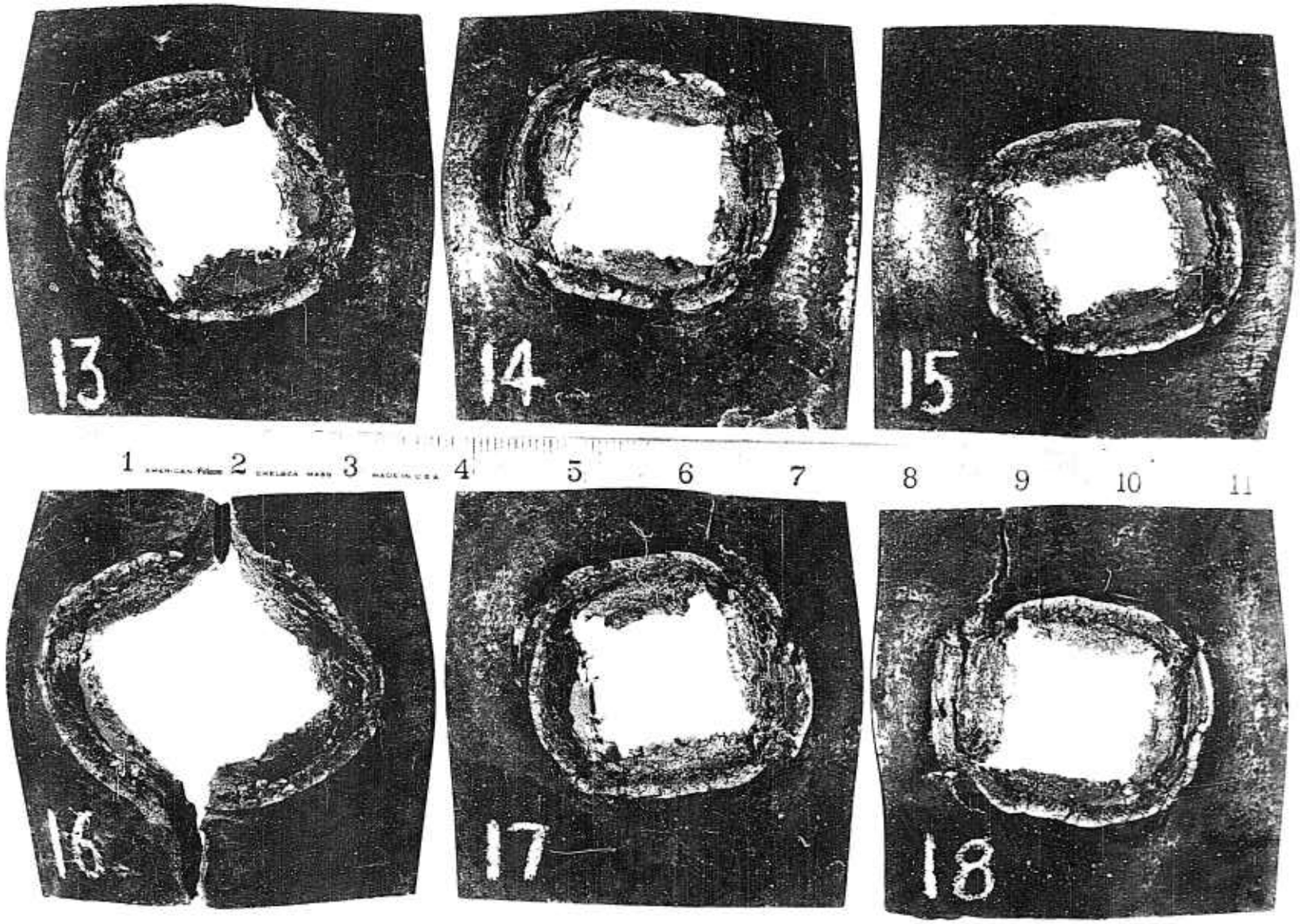
By observation of the holes blown in the steel test plates the minimum point of high order detonation was determined to be 5 grains of Cyclonite. Fifty percent additional Cyclonite is included for a factor of safety, so that the charge required is placed at 7.5 - 8.0 grains.



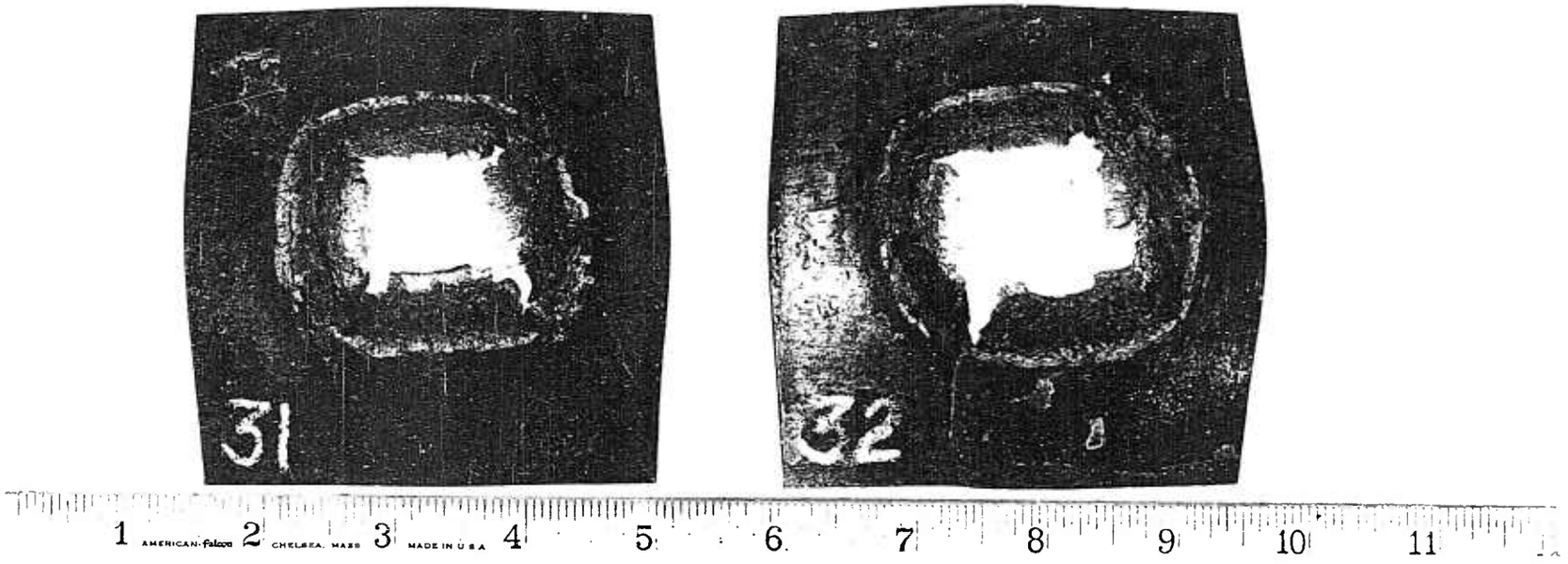
5.8 Base Charge Test - Test Plates



5.8 Base Charge Test - Test Plates (Continued)



5.8 Base Charge Test - Test Plates (Continued)



5.8 Base Charge Test - Test Plates (Continued)

5.9 High Temperature Storage Test (First Month) Data Sheet

Test Plan: To determine the effect of storage at high temperature on the initiation sensitivity of pressed TNT blocks and initiating ability of the non-electric blasting caps.

Test Specimens: (1) 1/2 pound pressed TNT blocks as per JAN-T-234, manufactured by the Kankakee Ordnance Works, Lot No. KNK-3-521 for the Corps of Engineers.
(2) T-7 Non-electric blasting caps.

Test Procedure and Conditions:

1. Each month up to a maximum of 6 months pressed TNT blocks and non-electric blasting caps are withdrawn from high temperature storage.

2. Caps are placed on the bottom of the base in the TNT block.

3. The TNT blocks are detonated on 1/2" thick steel plate.

4. The standards of comparison are results from detonation of pressed TNT blocks, T-7 blasting caps and standard commercial blasting caps stored at normal temperatures.

5. Oven temperatures for the first month's storage were 144°F minimum and 153° F maximum.

6. All TNT blocks are from the same production lot.

7. All T-7 blasting caps are from the same production lot.

8. The TNT blocks and caps used in the test August 19, 1954, were stored at high temperature for 31 days.

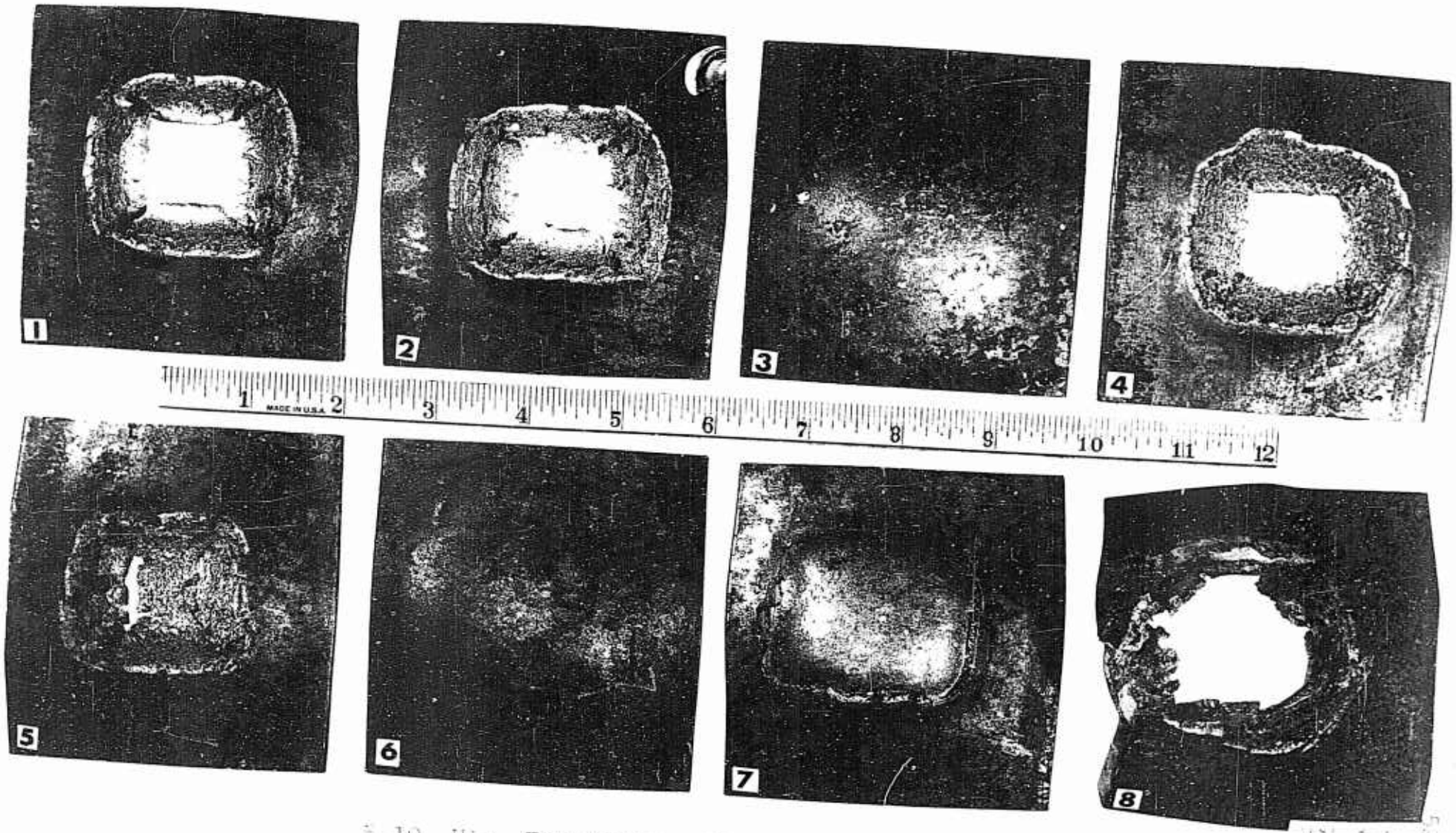
Test Results:

Test Plate #	Type of Storage 1/2 lb. TNT block	Type of Storage, T-7 Blasting Cap	Order of Detonation***
1	Normal	Normal	High
2	Normal	High Temperature	High
3	High Temperature	Normal	Low
4	High Temperature	Normal	High
5	High Temperature	High Temperature	High
6	High Temperature	High Temperature	Semi-High
7*	Normal	Normal	High
8**	Normal	Normal	High

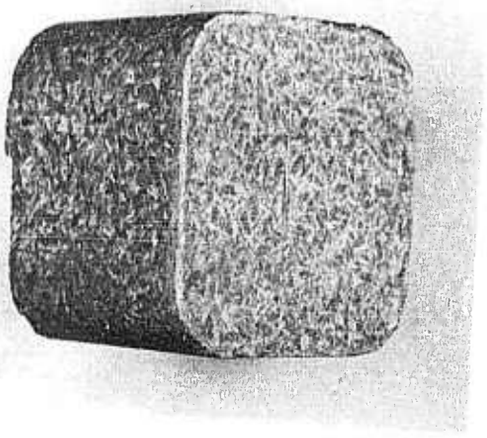
* Commercial blasting cap used.

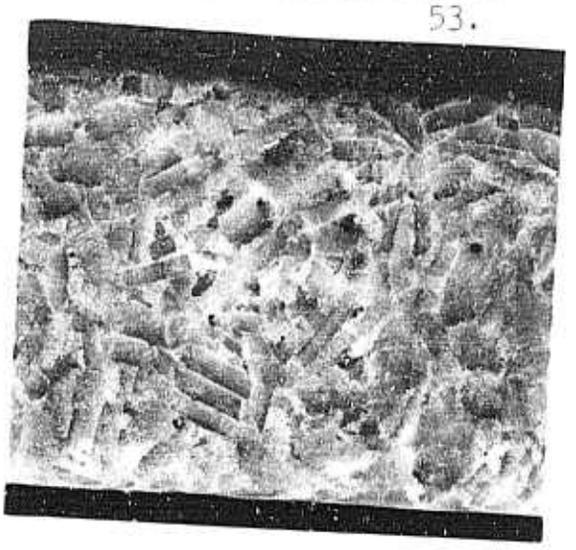
** A 14" length of Primacord was wrapped around the center of the TNT block and detonated with a commercial blasting cap.

*** See following page for photographs of TNT test plates.

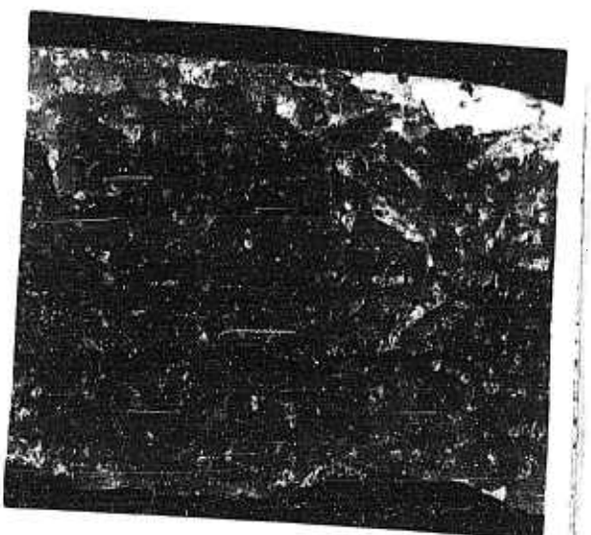


5.10 High Temperature Storage Test - Test Plates

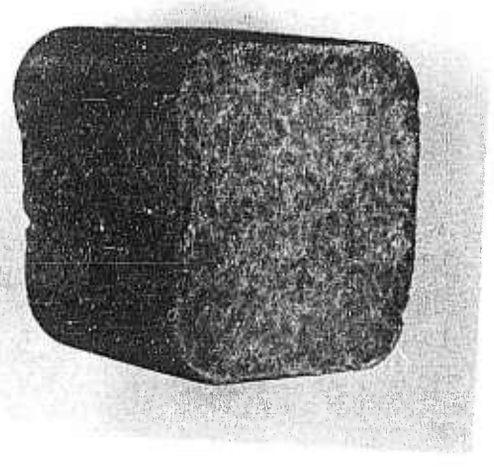


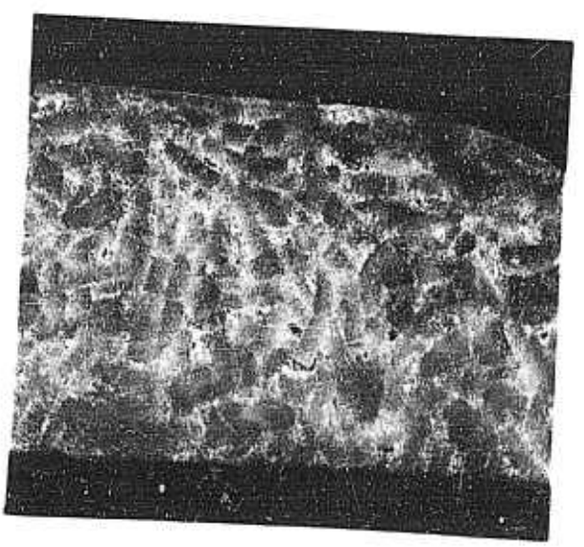


Pressed TNT Under Normal Storage.



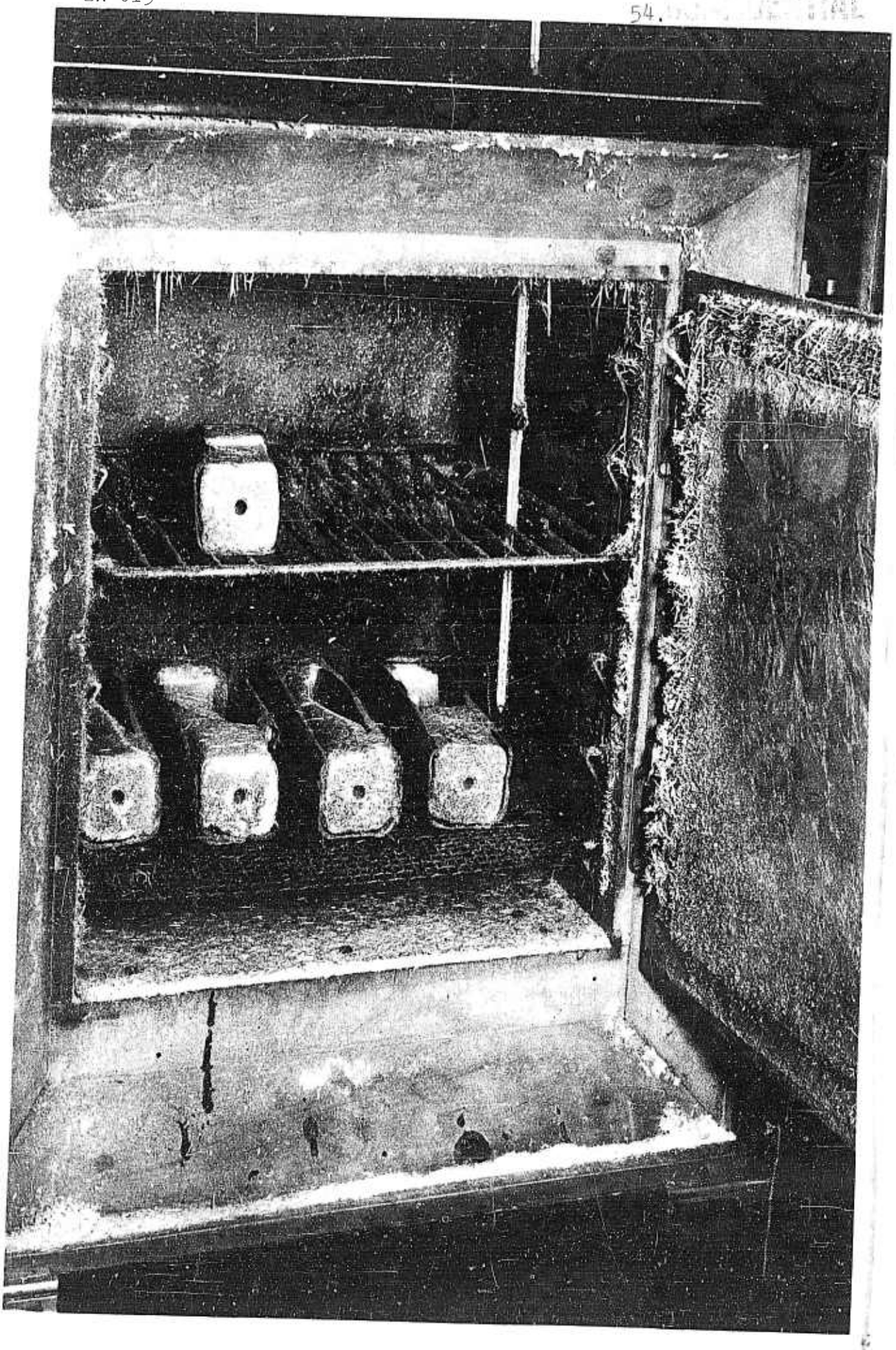
Cast TNT



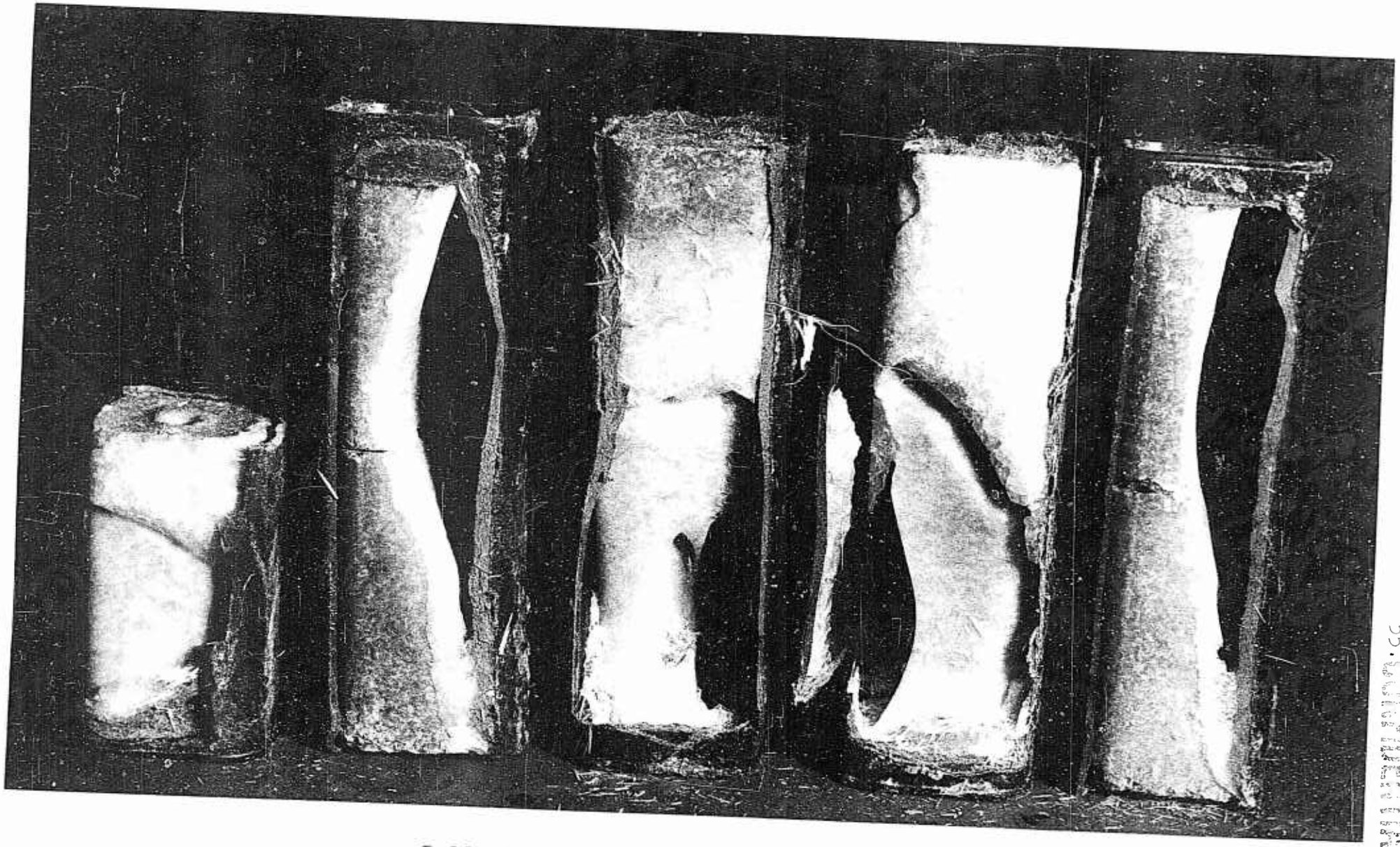


Pressed TNT Under 160°F Storage For 44 Days.

5.11 Comparison of Pressed, Cast and Stored TNT



5.12 Interior of Oven After TNT Storage Test



5.13 TNT Blocks After Storage Test

LINE NO.	NAME
1	ASSEMBLY
2	CUP
3	FERRULE
4	CHARGE, BASE
5	CHARGE, PRIMIN
6	CHARGE, IGNIT

.2 [illegible] GRAINS 270-70MG, LEAD AZIDE
SEE NOTE B

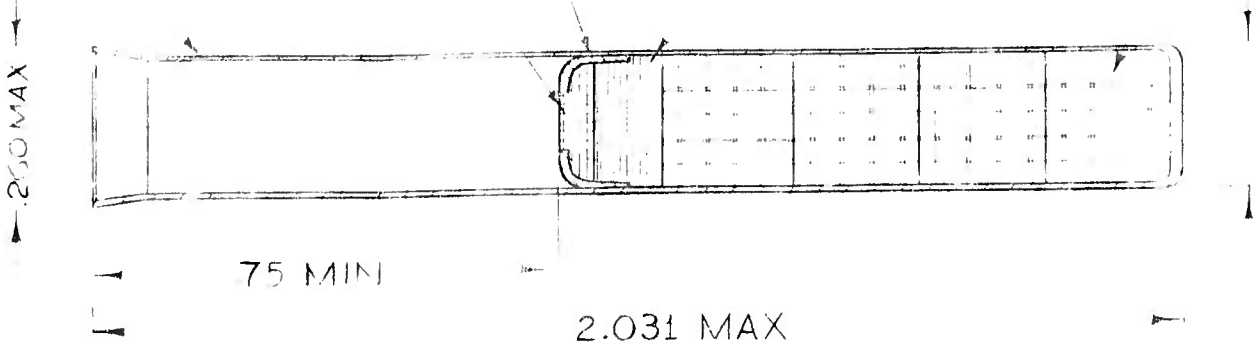
[illegible] GRAINS (4[illegible]-13MG) NORMAL LEAD STYPHNATE
SEE NOTE B

HARGE, P[illegible] P-88397A

14.5 [illegible] GRAINS 940-130 MG) RDX (CYCLONITE)
SEE NOTE A

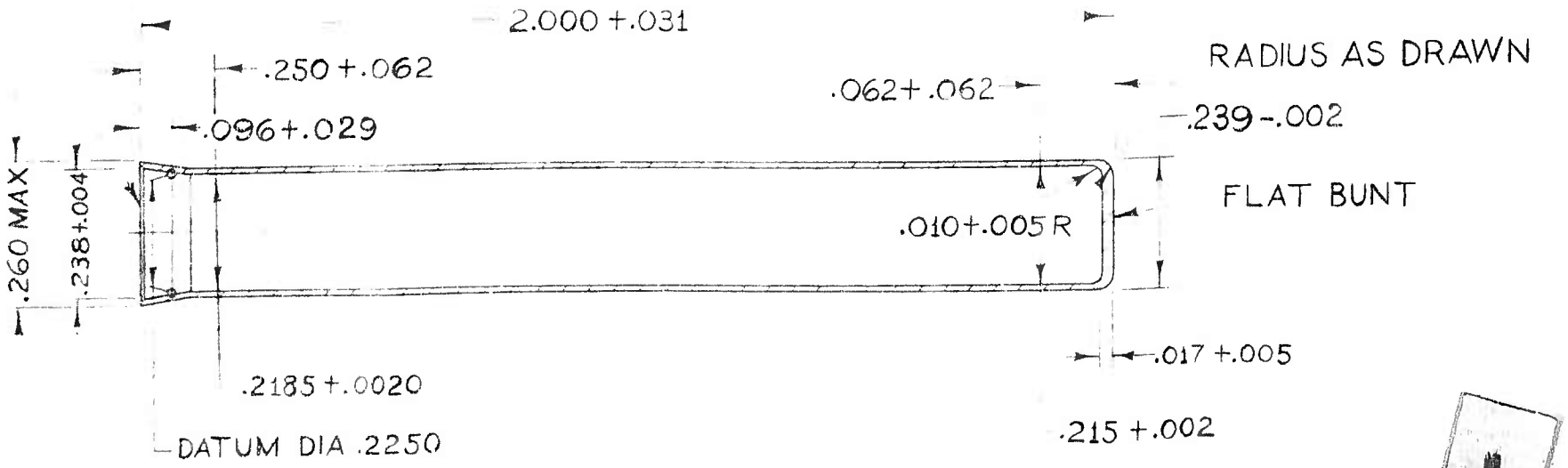
FERRULE
P-[illegible]7D

CUP P-88397E



ASSEMBLY P-88397

SLIGHT CHAMFER



CUP P-88397E
ALUMINUM, SHEET TEMPER O
FINISH AS DRAWN

LINE NO.	LIST
1	ALUMINUM AL
2	RDX
3	LEAD AZIDE
4	NORMAL LEA

1	ALUMINUM
2	RDX
3	LEAD AZI
4	NORMAL L

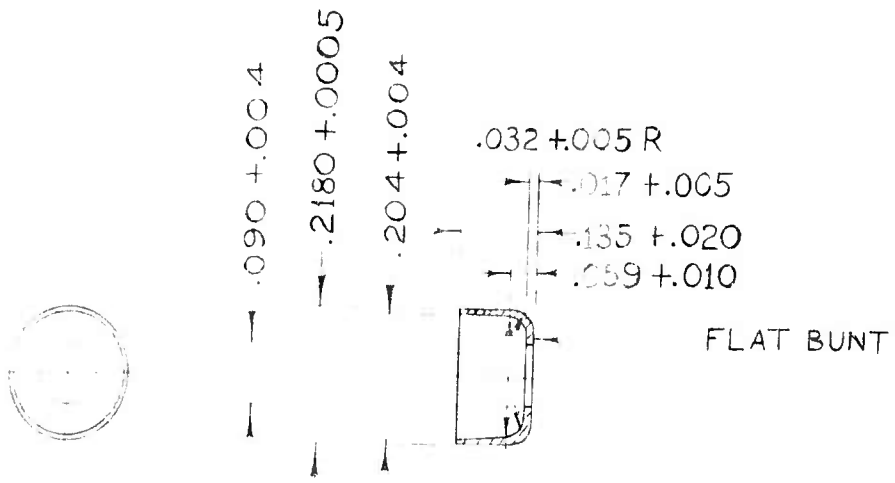
.017 +.005

.215 +.002

2.135 +.020

DATUM DIA .2250

CUP P-88397E
ALUMINUM, SHEET TEMPER O
FINISH AS DRAWN



FERRULE P-88397D
ALUMINUM, SHEET TEMPER O
FINISH AS DRAWN

NOTES:

A- PRESS BASE CHARGE (RDX) INTO CUP IN 4 INCREMENTS AT A PRESSURE BETWEEN 5000 AND 5600 LB PER SQ IN.

B- CHARGE THE IGNITER, PRIMING AND FERRULE IN THE ORDER GIVEN AND CONSOLIDATE IN ONE PRESS AT A PRESSURE BETWEEN 5000 AND 5600 LB PER SQ IN.

2

E)

F P-88397

LIST OF PARTS

LINE NO.	NAME OF PART	NO. REQD PER COMPONENT	PIECE MARK	MATERIAL: SIZE OR FORM	MATERIAL: KIND	MATERIAL: GRADE	MATERIAL: SPEC NUMBER	APPROX UNIT WEIGHT GRAMS	APPROX GROSS WT OF RAW STOCK PER 1000 ASSEMBLIES	REMARKS
1	ASSEMBLY									
2	CUP	1		SHEET	ALUMINUM	SHEET TEMPERO	QQ-A-318b			
3	FERRULE	1		SHEET	ALUMINUM	SHEET TEMPERO	QQ-A-318b			
4	CHARGE, BASE	1			RDX	TYPE A	PA-PD-416			
5	CHARGE. PRIMING	1			LEAD AZIDE		MIL-L-3055			
6	CHARGE, IGNITER	1			NORMAL LEAD STYPHNATE		PA-PD-180			

LIST OF STANDARDS AND SPECIFICATIONS

LINE NO.	LIST OF STANDARDS AND SPECIFICATIONS	SPEC OR STD NO.	REQUIRED BY
1	ALUMINJM ALLOY. 52S, PLATE AND SHEET	QQ-A-318b	
2	RDX	PA-PD-416	
3	LEAD AZIDE	MIL-L-3055	
4	NORMAL LEAD STYPHNATE	PA-PD-180	

1	ALUMINUM	PA-PD-416
2	RDX	MIL-L-3055
3	LEAD AZIDE	FA-PD-180
4	NORMAL LEAD STYPHNATE	

5600 LB PER SQ IN.
E PRESS AT A

SYM	DESCRIPTION	DATE	APPROVAL

REVISIONS

PHYSICAL PROPERTIES	
YP	
TS	
EL 2	
RA	
BH	
RH	

NEXT ASSY	USED ON

APPLICATION

DO NOT APPLY PART NO.

DO AS SPECIFIED

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

TOLERANCES ON DECIMALS ±.010

ANGLES FRACTIONS

MATERIAL AS NOTED

HEAT TREATMENT

FINAL PROTECTIVE FINISH

ORIGINAL DATE OF DRAWING APRIL 10 56

DRAFTSMAN JVT	CHECKER
TRACER	CHECKER M.E.E.
ENGINEER LES	ENGINEER

SUBMITTED ORD CORPS

APPROVED BY ORDER OF THE CHIEF OF ORDNANCE ORD CORPS

CAP, BLASTING NON-ELECTRIC T7 ASSEMBLY AND DETAILS PROJ TA 3-5306

SCALE 8 = 1 UNIT WT

ORDNANCE CORPS
DEPT OF THE ARMY

DWG SIZE F

P-88397

SHEET 1 OF 1

CHARGE, IGNITER P-88398 B
4.2 - 1.0 GRAINS (270 - 70 MG) LEAD AZIDE
SEE NOTE E

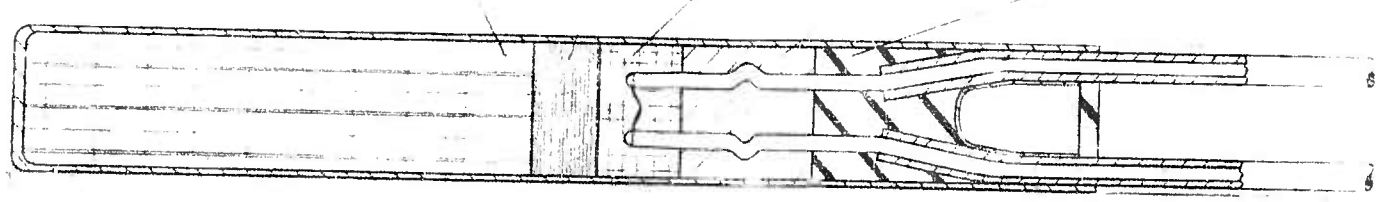
CHARGE, BASE P-88398 A
14.5 - 2.0 GRAINS (940 - 130 MG) RDX, TYPE A
SEE NOTE A

CHARGE, PRIMING P-88398 C
3.0 - 0.8 GRAINS (200 - 50 MG) IGNITER (SEE LINE 8, LIST OF PARTS)
SEE NOTE C

PLUG P-88399 B

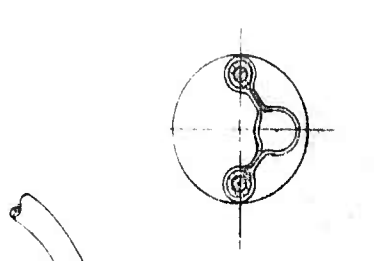
CUP P-88399 A

COMPOUND, SEALING P-88398 D



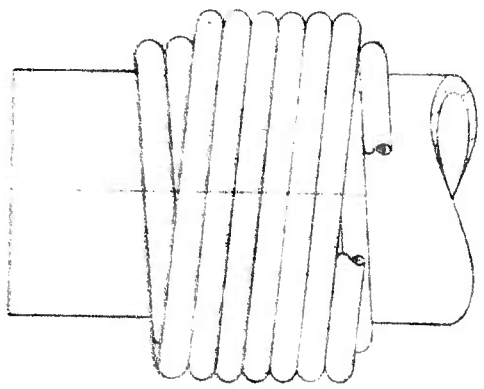
2.031 MAX

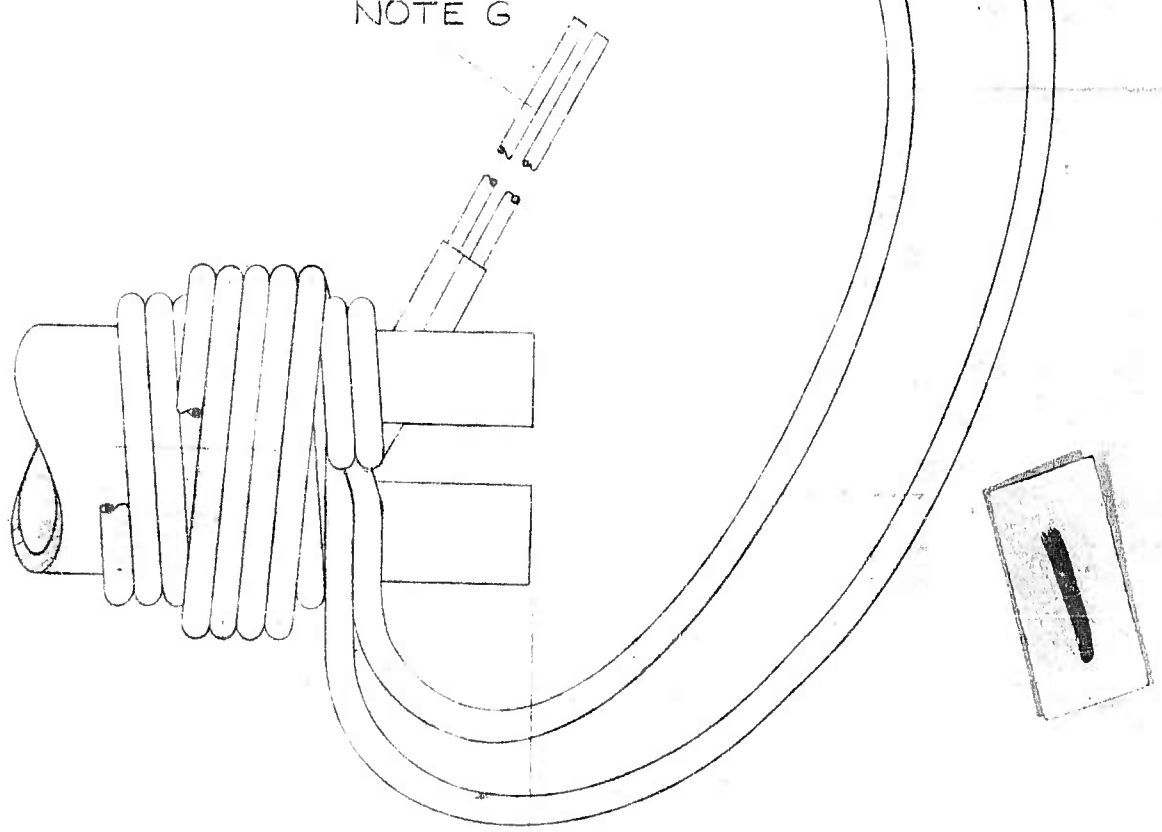
.241 MAX



NOTE G

SPOOL P-88399 C





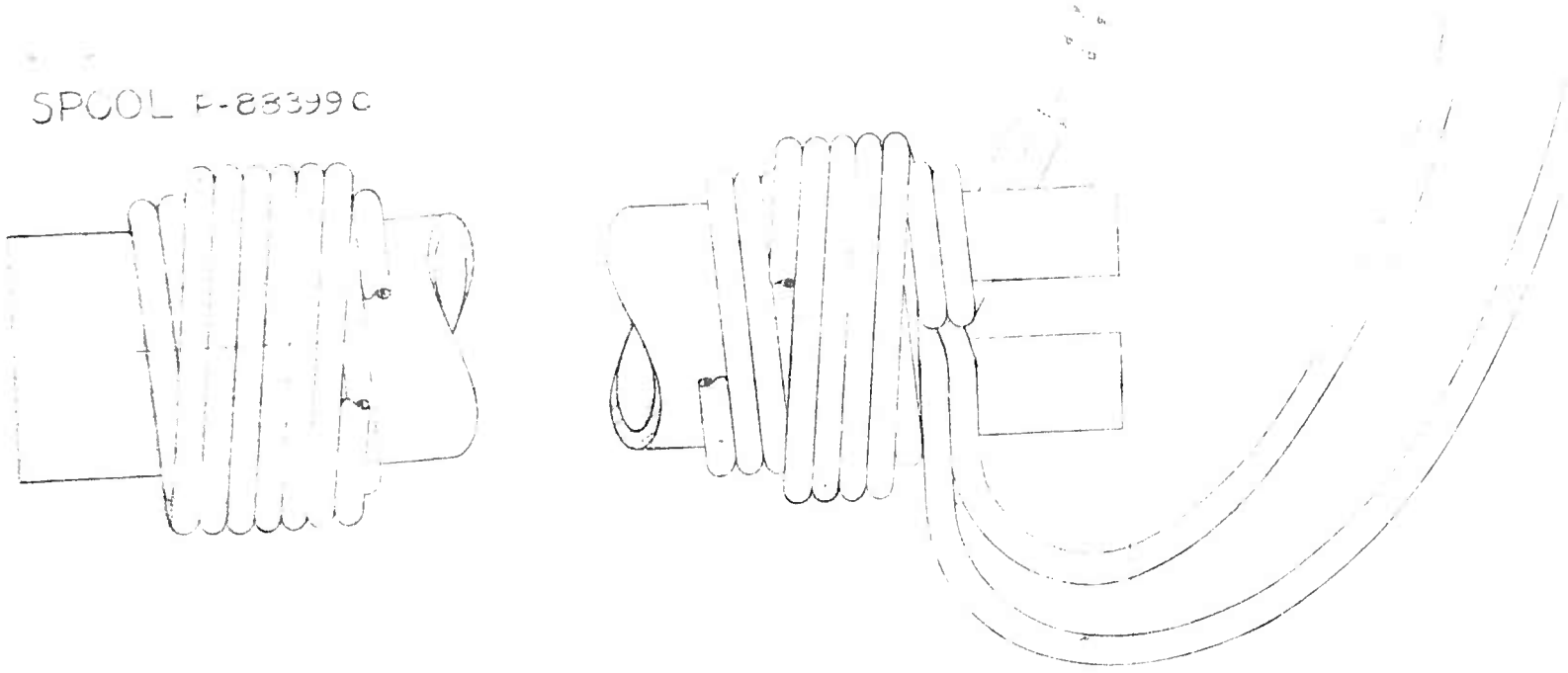
4.885 MAX

LINE NO.	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	S
13	
14	S
15	
16	
17	

a - ETH
b - WE
c - AM
d - EC
POL
ACI
e - UNE
f - SOL
g - "CA
NE
h - SO
i - BR

LINE NO.	
1	A
2	R
3	LE
4	BA

SPOOL P-88399C



4.885 MAX

ASSEMBLY P-88398

NOTES:

A- THE BASE CHARGE (RDX) IS PRESSED INTO THE CUP IN 4 INCREMENTS AT PRESSURE BETWEEN 5000 AND 5600 LB PER SQ INCH.

B- THE PRIMING CHARGE (LEAD AZIDE) IS PRESSED IN ONE INCREMENT AT A PRESSURE BETWEEN 5000 AND 5600 LB PER SQ INCH.

C- THE IGNITER IS CONSOLIDATED BY PRESSING IT WITH THE SULFER PLUG, USING THE LEAD WIRES TO APPLY THE PRESSURE, OR BY A COMPARABLE METHOD.

D- THE SEALING COMPOUND IS INJECTED INTO THE CUP AFTER CRIMPING AND CURED AT 70° TO 110° F. FOR 36 HOURS.

E- THE RESISTANCE OF THE ASSEMBLED DETONATOR IS BETWEEN 1.35 AND 1.65 OHMS.

F- THE DETONATOR IS PLACED INSIDE THE SPOOL PRIOR TO SHIPMENT.

G- TWIST ENDS OF LEAD WIRE TOGETHER FOR A MINIMUM OF THREE TURNS.

f- SOLDER APPLIED IN A

g- "CALAHAN", SOLDERI
NEW JERSEY, (OR EQ

h- SOWYA PROTIEN AD

i- BRIDGE WIRE IS NO.

LINE NO.	LIST OF SPE
1	ALUMINUM ALLO
2	RDX
3	LEAD AZIDE
4	BARIUM CHROMA
5	SOLDER
6	APPLICATION
7	COATED WIRE FL
8	
9	
10	

LINE NO.	LIST OF PI
1	CAP BLAST
2	CAP BLASTING E
3	

LIST OF PARTS

LINE NO.	NAME OF PART	NO. REQD PER COMPONENT	PIECE MARK	MATERIAL: SIZE OR FORM	MATERIAL: KIND	MATERIAL: GRADE	MATERIAL: SPEC NUMBER	APPROX UNIT WEIGHT GRAMS	APPROX GROSS WT OF RAW STOCK PER 1000 ASSEMBLIES	REMARKS
1	ASSEMBLY									
2	CUP	1		SHEET	ALUMINUM	SHEET TEMPER O	QQ-A-318 b			
3	PLUG	1		CAST	SULFER					
4	WIRE, LEAD	2		WIRE	TINNED COPPER		COMMERCIAL			a
5	WIRE, BRIDGE	1		WIRE	NOBLE METAL		COMMERCIAL			i
6	CHARGE, BASE	1			RDX	TYPE A	PA-PD-416			
7	CHARGE, PRIMING	1			LEAD AZIDE		MIL-L-3055			
8	CHARGE, IGNITER	1			60% BLANK FIRE POWDER					b
9					18% BASIC LEAD STYPHNATE					c
10					22% BARIUM CHROMATE	CLASS A	JAN-B-550			
11										
12	SEALING COMPOUND				100 PARTS EC 1130					d
13					15 PARTS EC 1063					
14	SPOOL	1			PAPER					e,h
15										
16					SOLDER	SN 50	QQ-S-571			f
17					FLUX					

a - ETHYL CELLULOSE COVERED, MEETING MIL-C-442A FLEXIBILITY TEST.
b - WESTERN BLANK FIRE POWDER. 100% THROUGH 80 MESH SCREEN. PRESENT GOVERNMENT BLANK FIRE SPEC DOES NOT APPLY.
c - AMORPHOUS BASIC LEAD STYPHNATE.
d - EC 1130 AND EC 1063 ARE MANUFACTURED BY MINNESOTA MINING AND MANUFACTURING COMPANY. EC 1130 CONTAINS LIQUID POLYSULFIDE, PHENOLIC RESIN, STEARIC ACID, ZINC SULFIDE AND BARIUM SULFATE. EC 1063 CONTAINS LEAD DIOXIDE, STEARIC ACID AND DIBUTYL PHTHALATE.
e - UNBLEACHED OR SEMI-BLEACHED KRAFT PULP PAPER, COLORED WITH A FADE-PROOF DYE (RED)
f - SOLDER APPLIED IN ACCORDANCE WITH MIL-S-6872.
g - "CALAHAN" SOLDERING, TINNING AND BABBITING FLUID (CONTAINS NO ACID). MADE BY GEORGE CALAHAN & CO. INC., CLOSTER, NEW JERSEY. (OR EQUIVALENT)
h - SOWYA PROTIEN ADHESIVE USED FOR SEALING PAPER OF SPOOL.
i - BRIDGE WIRE IS NO. 850 Pt. AVAILABLE AT SIGMUND COHN MFG. CO., MT. VERNON, N.Y.

3

LINE NO	LIST OF SPECIFICATIONS AND STANDARDS	SPEC OR STD NO.	REQUIRED BY
1	ALUMINUM ALLOY, 52S, PLATE AND SHEET	QQ-A-318 b	
		PA-PD-416	
	RDX		

LINE NO.	LIST OF SPECIFICATIONS AND STANDARDS	SPEC OR STD NO.	REQUIRED BY
1	ALUMINUM ALLOY, 52S, PLATE AND SHEET	QQ-A-318b	
2	RDX	PA-PD-416	
3	LEAD AZIDE	MIL-L-3055	
4	BARIUM CHROMATE, CLASS A	JAN-B-550	
5	SOLDER	QQ-S-5716	
6	APPLICATION OF SOLDER	MIL-S-6872	
7	COATED WIRE FLEXIBILITY SPECIFICATIONS	MIL-C-442A	
8			
9			
10			

57

LINE NO.	LIST OF DRAWINGS	DRAWING NUMBER
1	CAP, BLASTING, ELECTRIC, T6, ASSY	
2	CAP, BLASTING, ELECTRIC, T6, DETAILS	
3		

4

SYM	DESCRIPTION	DATE	APPROVAL

REVISIONS

PHYSICAL PROPERTIES			
YP			
TS			
EL-2			
RA			
BH			
RH			

NEXT ASSY	USED ON

APPLICATION

DO NOT APPLY PART NO.

DO AS SPECIFIED

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

TOLERANCES ON DECIMALS

ANGLES FRACTIONS

MATERIAL

HEAT TREATMENT

FINAL PROTECTIVE FINISH

ORIGINAL DATE OF DRAWING APRIL 10 '56

DRAFTSMAN JVT CHECKER

TRACER CHECKER M.E.E.

ENGINEER LES ENGINEER 7/15

SUBMITTED ORD CORPS

APPROVED BY ORDER OF THE CHIEF OF ORDNANCE ORD CORPS

CAP, BLASTING ELECTRIC T6 ASSEMBLY PROJ TA 3-5306

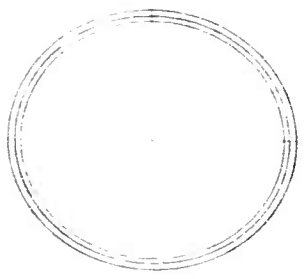
SCALE 4 = 1 UNIT WT

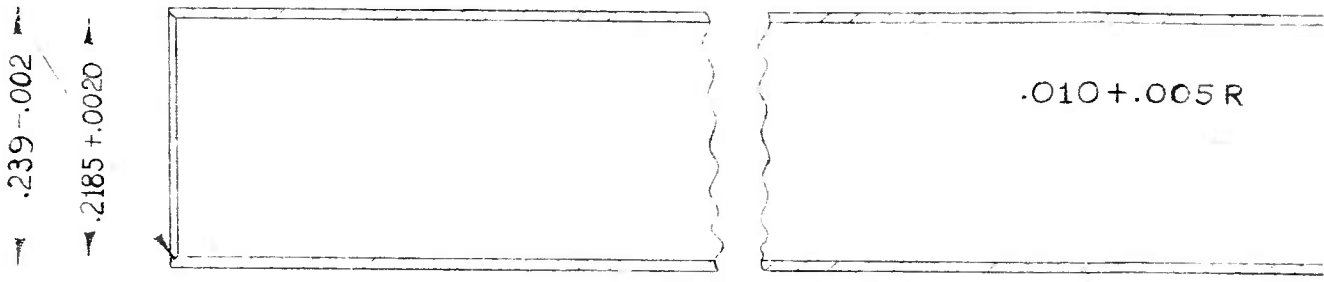
ORDNANCE CORPS DEPT OF THE ARMY

DWG SIZE F P-88398

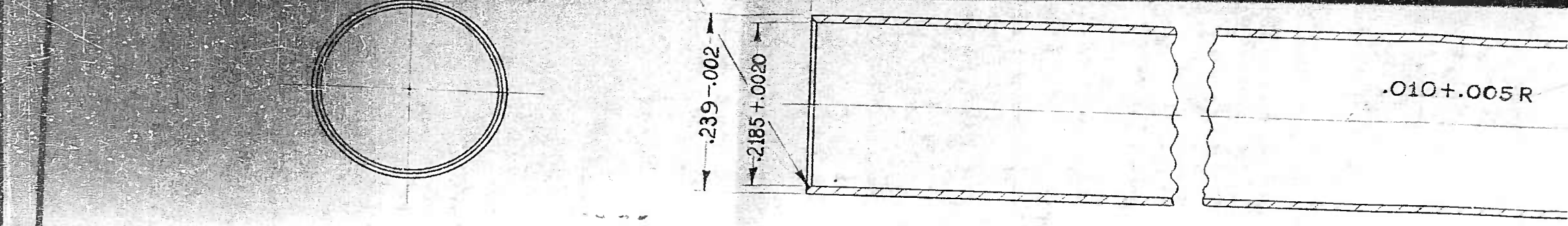
SHEET 1 OF 1

SLIGHT CHAMFER OR RADIUS





CUP P-88399A
ALUMINUM, SHEET TEMPER O
FINISH AS DRAWN



CUP P-88399A
ALUMINUM, SHEET TEMPER O
FINISH AS DRAWN

2

NOTES:

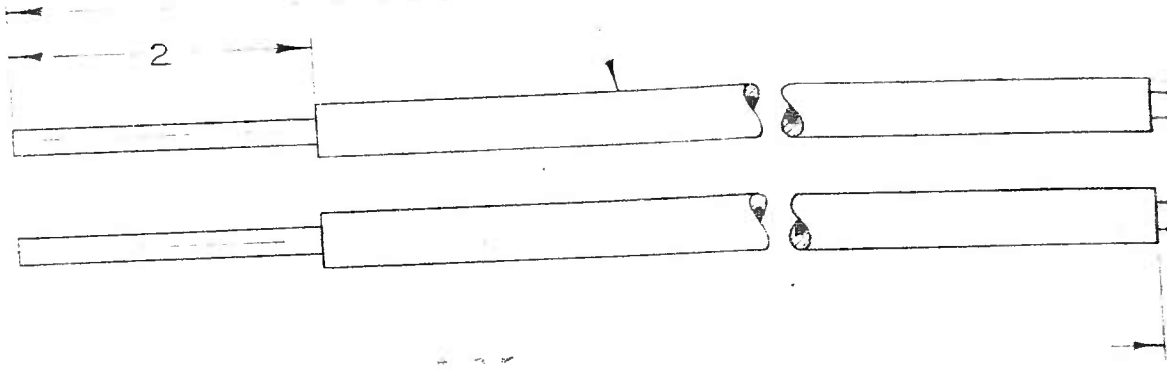
A. THE RESISTANCE OF THE PLUG WITH BRIDGEWIRE AND 12 FT LEADS TO BE BETWEEN 1.35 AND 1.65 OHMS.
B. THE INSULATED LEAD WIRE MUST COMPLY WITH THE FLEXIBILITY TEST IN MIL-C-442A.
C. SOLDER TO BE APPLIED IN ACCORDANCE WITH MIL-S-6872.
D. 12 FT LEADS TO BE WOUND ON THE SPOOL
E. AFTER BRIDGEWIRE IS SOLDERED IN PLACE ENDS OF LEAD WIRES ARE CRIMPED INWARD TO DIMENSION SHOWN TO RELIEVE BRIDGE WIRE TENSION.

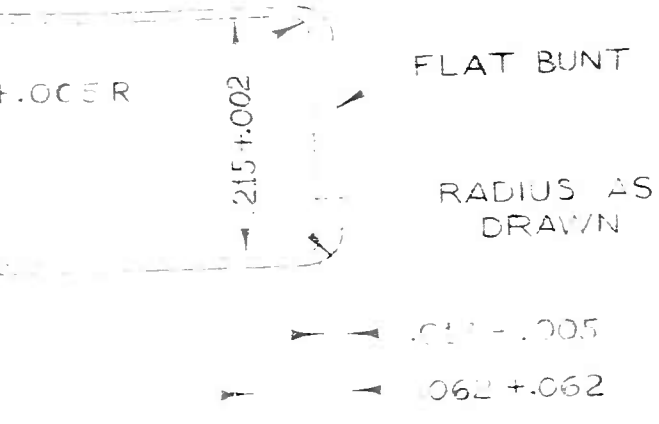
WIRE, BRIDGE F
.00095 DIA, 80% PLA
15% RHODIUM AND 5%
RESISTANCE 18

WIRE, LEAD P-88399D
NO. 22 AWG TINNED COPPER
COATED WITH ETHYL CELLULOSE
APPROX .010 THICK
SEE NOTE B

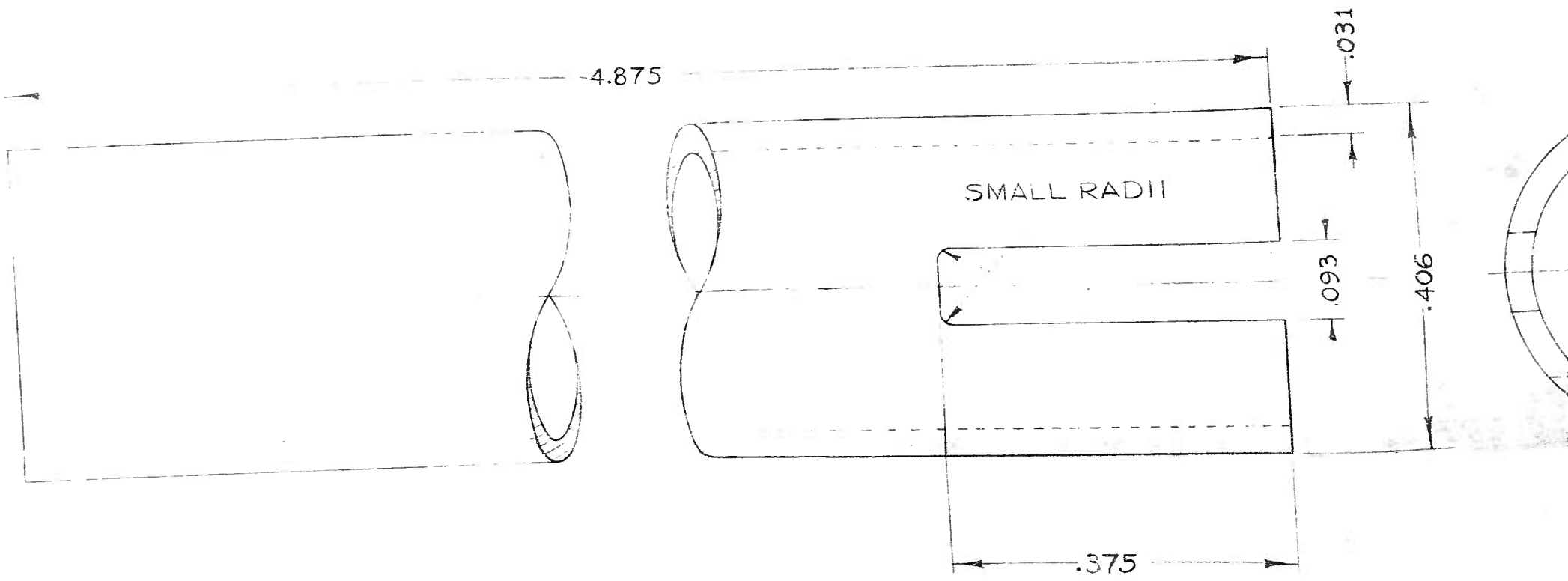
3

NOTE D

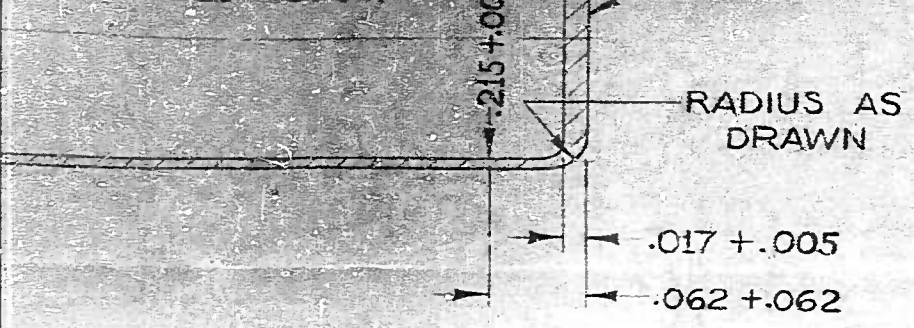




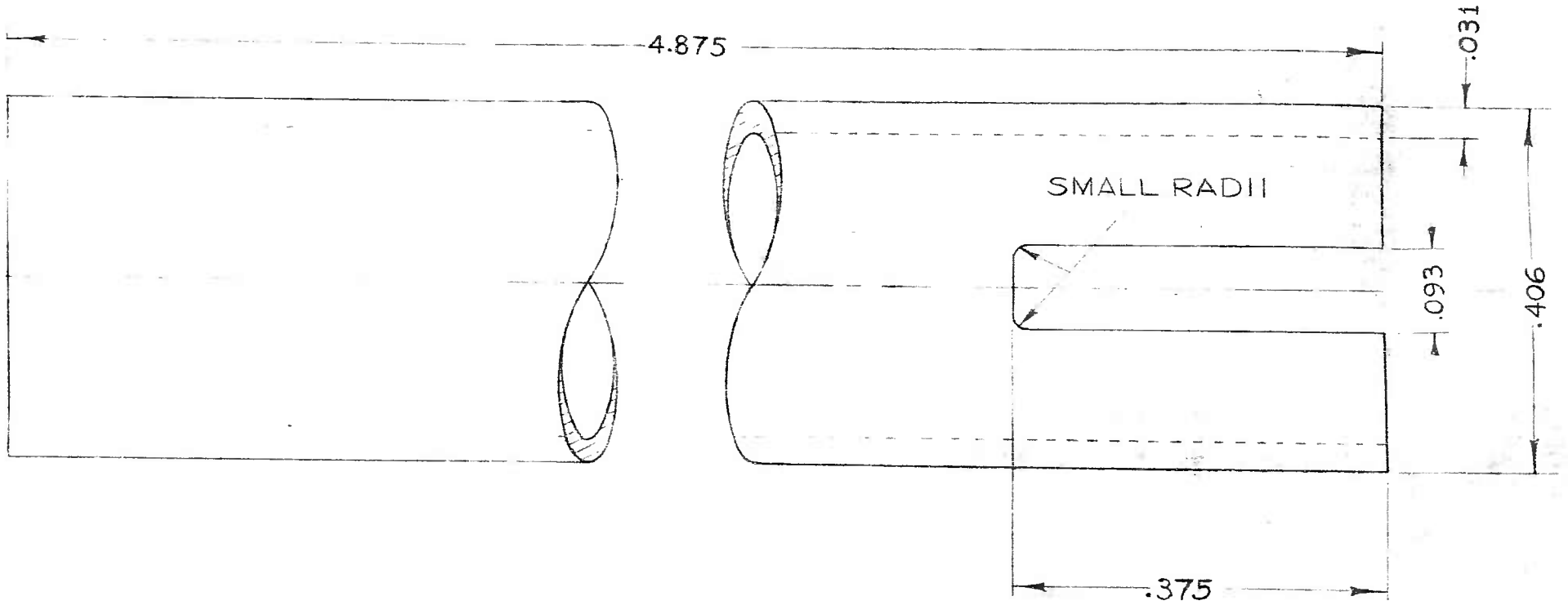
PLUG P-88399
CAST SULFER: 97% RHOM
2% MICA AND 1% FLAKE



SPOOL P-88399C
UNBLEACHED OR SEMI-BLEACHED KRAFT PULP PAPER
AND COLORED WITH A RED FADEPROOF DYE



PLUG
CAST SULFER
2% MICA AND



SPOOL P-88399C
UNBLEACHED OR SEMI-BLEACHED KRAFT PULP PAPER
UNSIZED AND COLORED WITH A RED FADEPROOF DYE
PAPER THICKNESS .0300+.0005

PHYSICAL PROPERTIES	
YP	
TS	
EL 2	
RA	
BH	
RH	

NEXT ASSY	USED ON
APPLICATION	
DO NOT	APPLY PART NO.
DO	AS SPECIFIED

UNLESS O
TOLER
ANGLES
MATER
HEAT T
FINAL

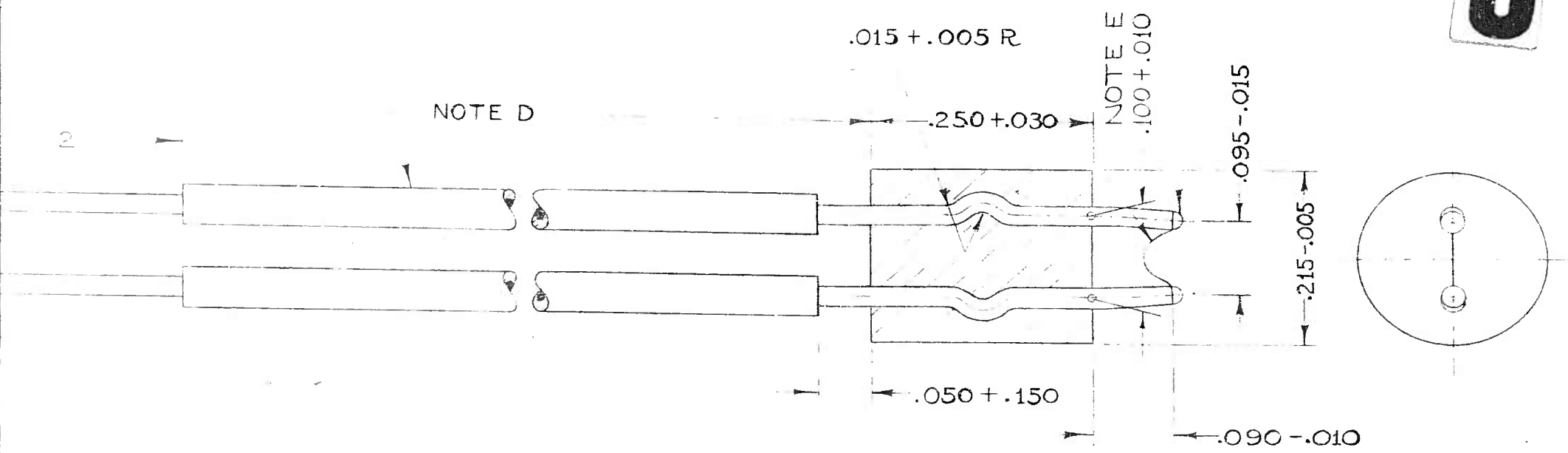
CONFIDENTIAL SECURITY INFORMATION

WIRE, BRIDGE P-88399 F
.00095 DIA, 80% PLATINUM
15% RHODIUM AND 5% RUTHENIUM
RESISTANCE 187 OHMS PER FT

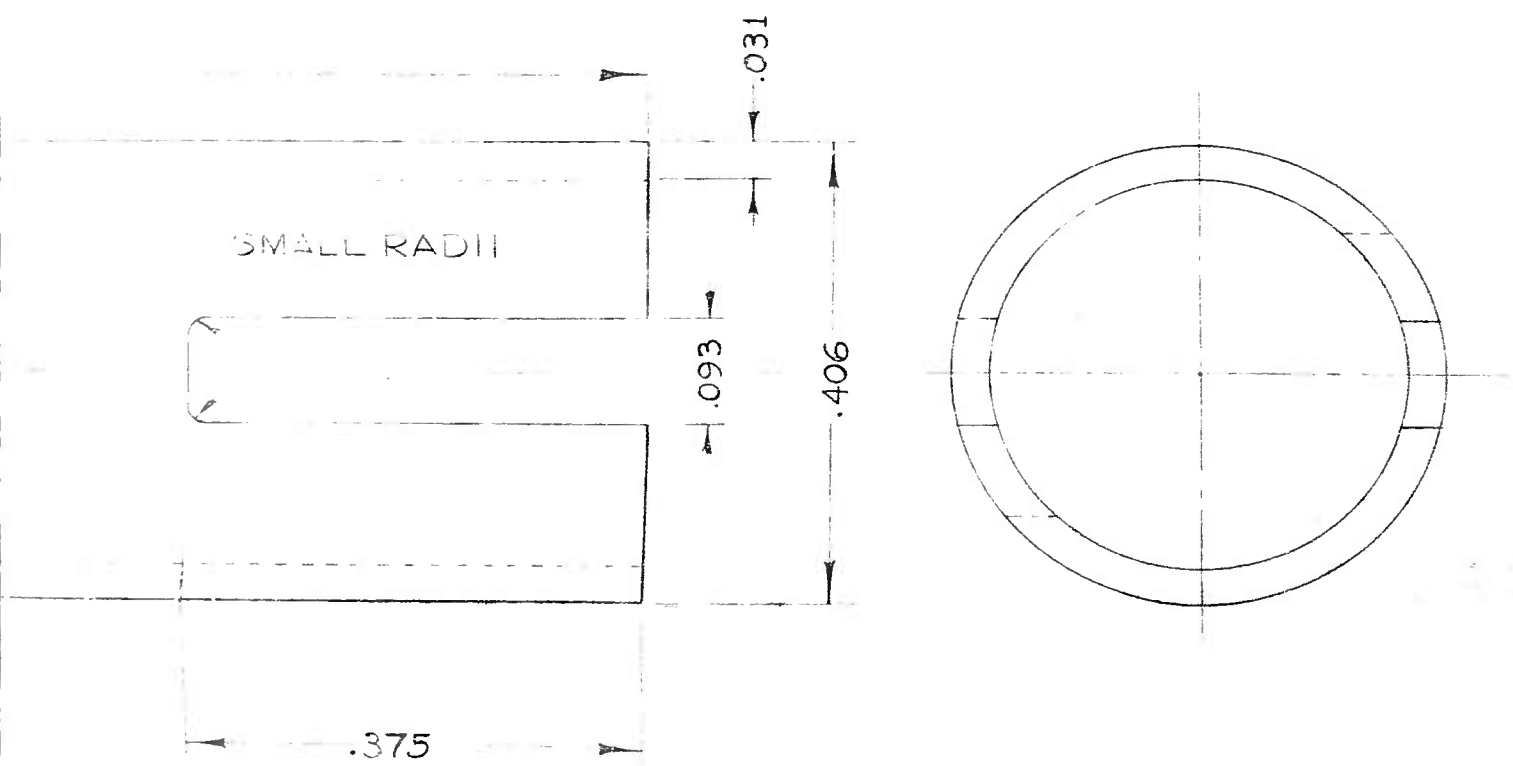
WIRE, LEAD P-88399 D
NO. 22 AWG TINNED COPPER
COATED WITH ETHYL CELLULOSE
APPROX .010 THICK
SEE NOTE B

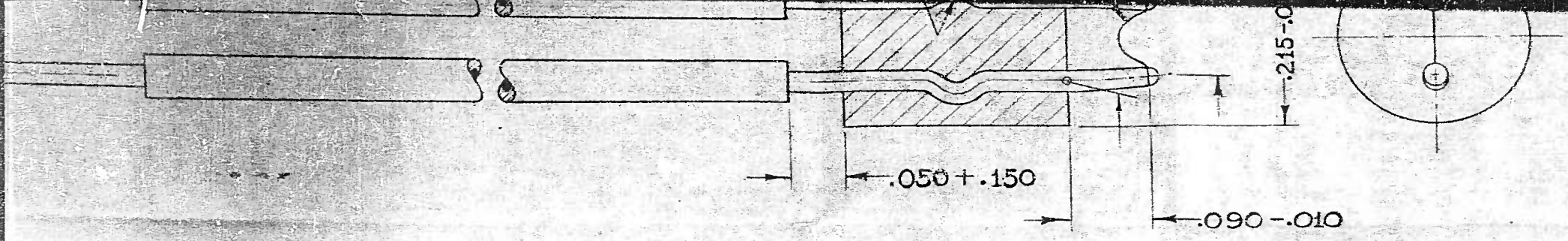
SOLDER P-88399 E
COMPOSITION SN 50
SEE NOTE C

5

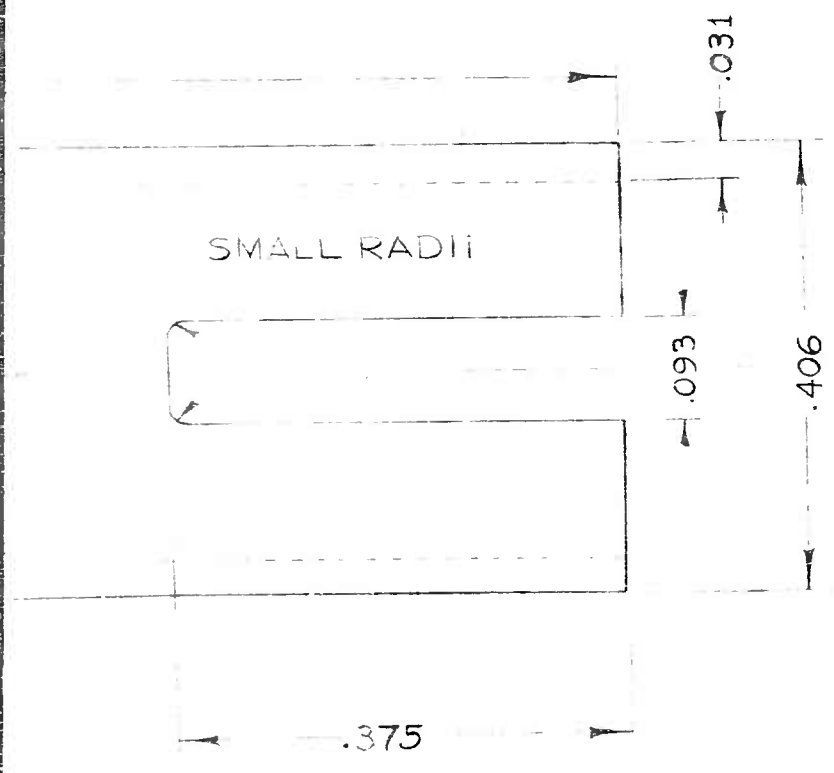


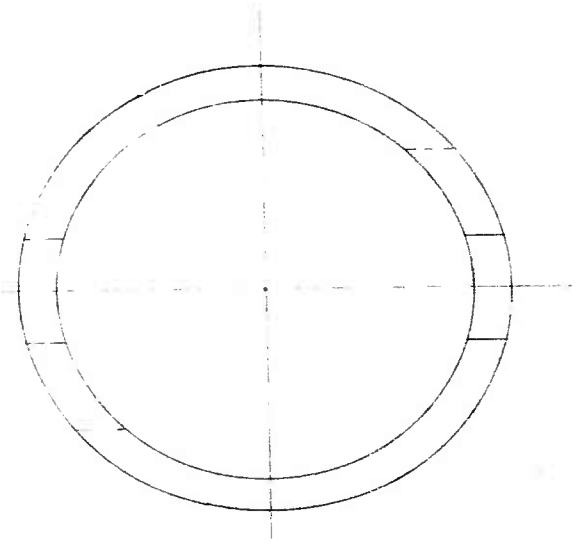
PLUG P-88399 B
CAST SULFER: 97% RHOMBIC SULFER
2% MICA AND 1% FLAKE GRAPHITE





PLUG P-88399B
CAST SULFER: 97% RHOMBIC SULFER
2% MICA AND 1% FLAKE GRAPHITE





6

AFT PULP PAPER
FADEPROOF DYE
0+.0005

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SYM	DESCRIPTION	DATE	APP

REVISIONS

PHYSICAL PROPERTIES			
YP			
TS			
EL 2			
RA			
BH		NEXT ASSY	USED ON
RH		APPLICATION	
		DO NOT	APPLY PART NO.
		DO	AS SPECIFIED

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
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ANGLES FRACTIONS
MATERIAL AS NOTED
HEAT TREATMENT
FINAL PROTECTIVE FINISH

ORIGINAL DATE OF DRAWING APRIL 10 '56
DRAFTSMAN JVT | CHECKER
TRACER | CHECKER M.E.E.
ENGINEER LES | ENGINEER
SUBMITTED ORD CORPS
APPROVED BY ORDER OF THE CHIEF OF ORDNANCE ORD CORPS

CAP, BLASTING ELECTRIC T6 DETAILS PROJ TA 3-5306

ORDNANCE C
DEPT OF THE A

SCALE 8 = 1 | UNIT WT

DWG SIZE F | P-883
SHEET 1 OF

ATION

6. SIGNATURE PAGE

OLIN MATHIESON CHEMICAL CORPORATION
Explosives Division

Lester E. Smith
Lester E. Smith
Project Engineer

Approved by:

M. E. Eilers
M. E. Eilers, Head
Military Projects Laboratory

F. R. Seavey, Chief
Detonator Research Section

for J. J. O'Neill
Manager, Research and Development
Department

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